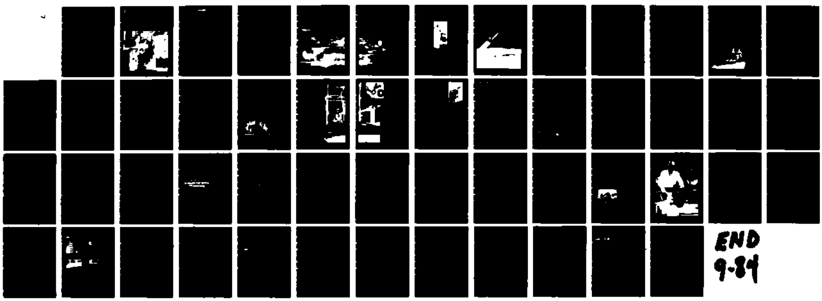
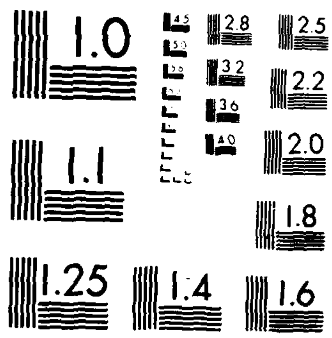
AD-A143 407 PROGRAM MANAGER: THE JOURNAL OF THE DEFENSE SYSTEMS MANAGEMENT COLLEGE VOLUME 13 NUMBER 3 MAY-JUNE 1984(U) DEFENSE SYSTEMS MANAGEMENT COLL FORT BELVOIR VA R W MOORE JUN 84 1/1

UNCLASSIFIED F/G 5/1 NL



END
9-84



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

May June 1984

Program Manager

The Journal of the Defense Systems Management College

Robots Make the Move Into the Work Place

This document has been approved for public release and sale; its

CONTENTS

Program Manager

Vol. XIII, No. 3
DSMC 60
May-June
1984

Program Manager (ISSN 0199-7114) is published bimonthly by the Defense Systems Management College, Fort Belvoir, Va. 22060, and is intended to be a vehicle for the transmission of information on policies, trends, events, and current thinking affecting program management and defense systems acquisition.

Statements of fact or opinion appearing in *Program Manager* are solely those of the authors and are not necessarily endorsed by the Department of Defense or the Defense Systems Management College. Unless copyrighted, articles may be reprinted. When reprinting, please credit the author and *Program Manager*, and forward two copies of the reprinted material to the Editor-in-Chief.

To subscribe, government personnel should submit written requests (using their business addresses) to the Editor-in-Chief. Nongovernment employees and organizations may subscribe at $14 annually through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Manuscripts and other correspondence are welcome and should be addressed to the Editor-in-Chief. Inquiries concerning proposed articles may be made by phone at (703) 664-5082/-5974 or AUTOVON 354-5082/-5974. Second class rate entered at Fort Belvoir, Va.

POSTMASTER: Send address changes to Editor-in-Chief, *Program Manager*, Defense Systems Management College, Fort Belvoir, Va. 22060.

A Survey of Air Force Acquisition Today

General Lawrence A. Skantze, USAF
Vice Chief of Staff, U.S. Air Force

■ *General Skantze was keynote speaker at the opening convocation for Program Management Course 84-1 in January. This article is based on his remarks.* ■

I've spent most of my life in research, development, and acquisition, and let there be no doubt about it, the acquisition process and program management are as important today as at any time in our history. Acquisition programs account for almost 45 percent of the total Department of Defense budget. In the Air Force, while many *support* the effort, fewer than 2 percent of our people are directly involved in contracting and program management. So the return on investment for the skills represented out there is very, very important. About 35 percent of the Air Force budget goes directly toward aircraft and missile procurement, and if you include military construction, research, development, test and evaluation, and other procurement, that total makes up 61 percent of the Air Force budget.

We've had a lot of controversy during this past year, as many of you are well aware. In fact, you would have had to have slept through the year not to have heard the horror stories about our spares-buying problems. Major systems such as the B-1B, the Peacekeeper, the F-18, the M-1 tank, and others also continue to get headlines and create great interest. To improve the acquisition process OSD initiated the DOD Acquisition Improvement Program. All services support that program, and you need to know what we in the Air Force are doing and where we're going.

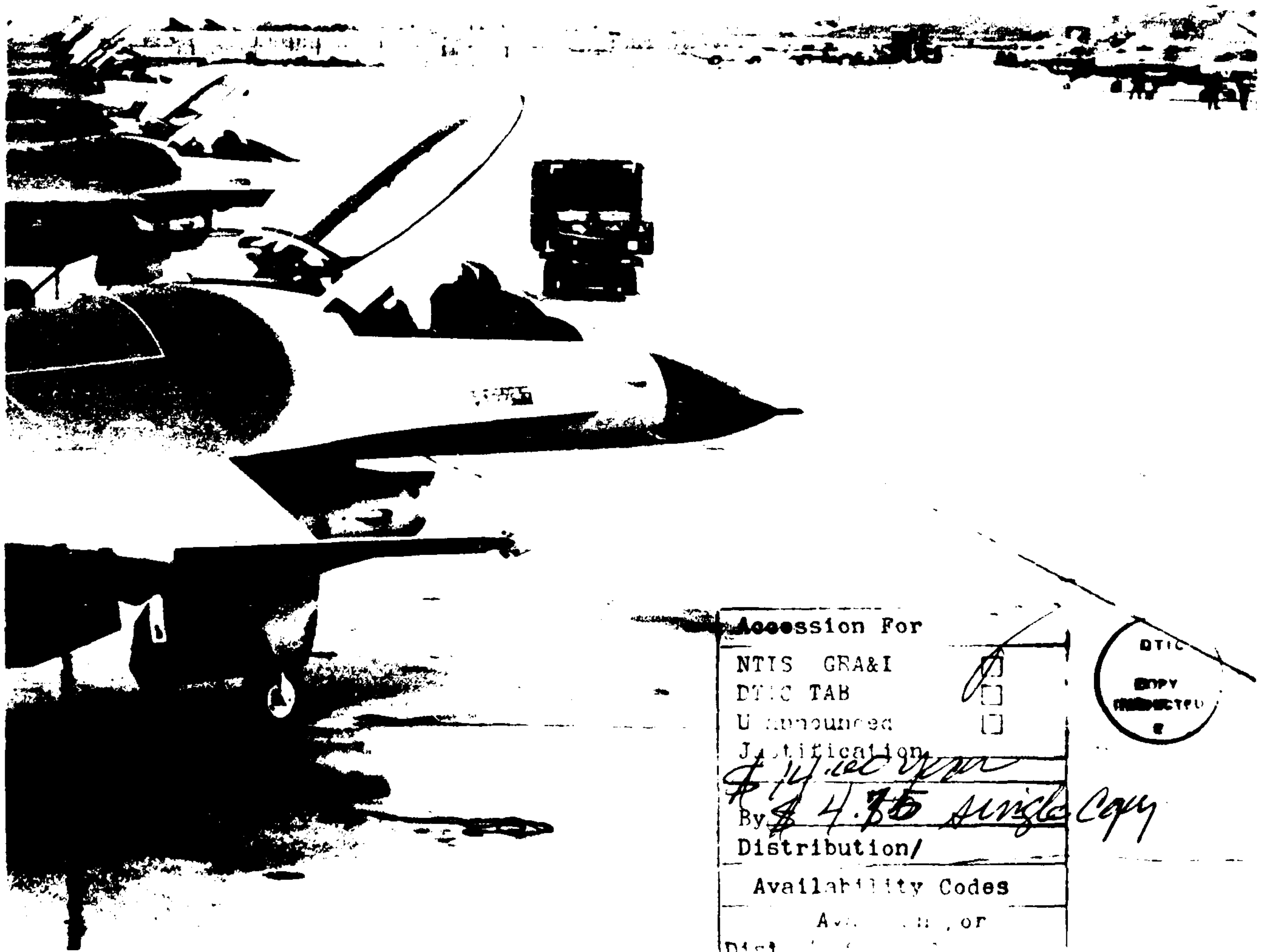
Basically, the program started with 32 initiatives under former Deputy Secretary of Defense Carlucci, but we've since scaled those down to concentrate on six major ones.

Program Stability

The first initiative, and probably the most important, is program stability. The problems here are slipping schedules, changing requirements, and escalating costs. In many instances our programs have gotten off track early in the process. I would say in *most* instances. When I was a young captain, a major general told me that the least risky part of the program is the definition phase. He said, "Once they decide to bend hardware, get out. Because through the definition phase, everything is on paper and you can change the paper. But once they bend the hardware it's going to be on the floor to embarrass you."

Just think: who ever overran the definition phase? The definition phase is always successful financially, but this sometimes leads to a euphoria that causes a lot of people to say, "Gee, this must have been the hard part; the rest of it is going to be easy." Not on your life. Next, changes are made to the original concept, sometimes without a lot of thought. We sacrifice the good while hunting for the best. And keep in mind that the better is always the enemy of the good. What you can get tomorrow looks so much better than what you're trying to produce and get out the door today. Changes like this disrupt the smooth progress in a program and, more important, cost us money.

F-16s on the flight line at Hill AFB, Utah.



o improve program stability, the Air Force has initiated what we call "program baselining and cost capping." Under this concept, programs are managed within the constraints of the defined baseline and cost cap. Simply stated, we get all the major players—operational command, development command, support command, and training command—to accept and agree, up-front, on the requirements, the program content, and the cost of the specific program. This is a very difficult process to pull off, but when you can finally get four 4-star signatures on that document and send it into the Pentagon, you have a lot of leverage with which to stabilize that program. For major weapons systems I also sign as the HQ USAF representative. Once this agreement is signed, we don't allow any changes unless everybody again agrees that those changes are vital. This doesn't include things like "make-work." We're always going to have engineering changes just to make things work, to make sure the frammis fits with the widget. I'm not talking about those things. I'm talking about gold-plated additional requirements.

Currently, for the '85 President's budget, programs planned for baselining include the C-5B transport aircraft, the Ground-Launched Cruise Missile, the B-1B strategic bomber, and the Peacekeeper (MX missile), among others. In this way we'll make changes with our eyes open and avoid the tendency to add on every bell and whistle that might become available.

The thing that really crystallized our ability to do this was the cap put on the B-1B program in fiscal year '81 when it was approved. I helped develop that baseline at $20.5 billion in '81 dollars and we've managed to adhere to it. That, as much as anything else, has helped us to sustain the program on the Hill—and we've just gone back and reaffirmed that number. It was our success with the cap on B-1B costs that convinced us that we ought to go to other major programs and put baselines and cost caps on them as well.

Multiyear Procurement

The second major initiative is multiyear procurement. Through fiscal 1984, estimated savings in the Air Force alone are more than $2.5 billion from multiyear contracts we already have on the books, not the least of which is the F-16, which came in at a lower negotiated multiyear contract than had been estimated. So I think that program has come through very well. There are many more opportunities for savings through multiyear contracting, but many of these opportunities are controversial. Here's why. When we sign

a multiyear contract, it helps program stability and reduces costs. But at the same time, it limits our programming flexibility. With a large percentage of our resources tied up in multiyear contracts, it can be very difficult to solve funding problems that arise when we put the annual Air Force budget together. Additionally, many in Congress are concerned over what they perceive to be a loss of federal budget flexibility arising from a multiyear contract. This concern was evidenced by their treatment of our fiscal 1984 budget request. Except for the B-1B and advance-buy parts for the defense satellite communication system, Congress did not approve any of our requested new multiyear procurement programs.

et, some amount of multiyear contracting is clearly in the best interest of the taxpayer, and we need to keep up our efforts to convince people of this. Bear in mind, too, that all of the resistance is not necessarily in the Congress. There's a good bit of it in DOD and even a good bit of it within the services. There are valid arguments that say you cannot afford to tie up a major percentage of your dollars in multiyear procurement. So you pick the ones that provide the most benefit to the government in terms of cost savings and program stability and you pursue those.

Economic Production Rates

The third initiative is economic production rates. Again, the success of this initiative depends on stable programs. Because of funding constraints, we too often establish lower than optimum production rates on some programs. I might conversely say that when you lay out programs, particularly in the definition phase, you often lay out unachievably high production rates. When I took over the AWACS program it had just started into development; it had gone through the definition phase. We were going to buy 42 AWACS in 2 years. That first year we were going to buy 19, and in the second year we were going to buy the balance. But there just wasn't any realistic way to get up the learning curve that fast. But as I said earlier, in the euphoria of program definition, you think you can always do those kinds of things, and as that 2-star said to me, do it, then leave the problem to someone else to wrestle with. So it's not an untruth that we have sometimes been overly optimistic about the rates at which we are going to produce a system and the ability of the budget to accommodate that much money.

Yet, more frequently, we "stretch out" programs. In developing the fiscal '84 budget, 30 of the 53 DOD-wide major programs were stretched out at reduced production rates—some to a significant degree, some to a lesser degree. The reasons for stretching these programs are many and understandable—technical problems, fiscal constraints, and simply too many programs to handle. Al-

though 9 of the 30 stretched programs were restored during the program budget decision process, too many remain with inefficient rates. We need to do a better job. In the Air Force, we have tasked our program element monitors to determine economic production rates for their programs and to describe variations that are acceptable. We will use this information as a guide to maintain rates that are efficient and affordable.

Regardless of your service or your program, you can expect increased emphasis on economic production rates, even if it means cancellation of some lower priority programs. And I might point out that for the past few years we have been trying to sustain the F-15 production rate on an annual basis of at least 42 aircraft, which tends to get you up in the knee of the efficiency curve. We have not been able to make that. A lot of the problem has been a perception in Congress that we ought to buy more F-16s and not F-15s. This is a case where year to year we constantly fight the battle to get an efficient production rate on the F-15. Again, this year we hope to get it up to 48 in the 1985 budget.

Realistic Budgeting

The fourth initiative is realistic budgeting, which is another big problem. President Eisenhower said in 1955 that as quickly as you start spending federal money in large amounts it begins to look like free money. Well, everyone knows it's not free money. We're trying to make our cost estimates more accurate. We're using better inflation estimates, and in the Air Force we're using the risk model to estimate costs associated with uncertainties in technology. We're also increasing the emphasis and frequency of independent cost analyses (ICAs). In 1983, we accomplished 16 ICAs compared to only 6 in 1981. In 1984, we expect to accomplish 16 to 20 ICAs. Again, though, program stability is the key. If we continue to change requirements, alter production rates, and otherwise modify the systems we're building, it will be impossible to get a handle on cost. Let me tell you, as program managers, one of your best tools is to get a group to run an ICA. Now, everybody in your program shop will say, "Hey, you don't want those guys in here. They really don't understand the program. The old man will get worried when he sees our numbers." Well, that's a lot of baloney. Put together a good professional team. Let them come at it from the outside, maybe with parametrics and past experience, whether they do it bottom up, parametrically, or top down. When they finish, it gives you another benchmark to look at. Particularly for a senior product division commander, it allows you to take the elements of the program and compare the estimates to find how yours differ from the ICA. Get to understand the differences! The fact that there are differences doesn't mean that you suddenly abandon your program manager and say, "You clown, you've missed the whole thing." What it really means is that you can, in your own mind and for your people, articulate the differences so that when you go into the next budget cycle, you're going to feel a lot more comfortable about what you're doing. So don't fight the ICA. The ICA is an in-house tool. My dictum is, I can use all the good help I can get. If someone has a good ICA team and wants to look at my program and give me another benchmark as to how I'm doing, that's free help. I don't pay a nickel for it. You want to capture these people, though, and make sure they get a good introduction and a thorough understanding of your program. Then let them do their thing and you take a look at the results.

First launch of the Ground-Launched Cruise Missile (GLCM). The GLCM is one of the programs planned for baselining in the '85 budget.


General Dynamics

Improved Readiness

Our fifth initiative is to improve readiness and logistics support. It does little good to have a weapon that isn't ready when you need it and where you need it—and for as long as you need it. Therefore, we're building in readiness and support right from the start. And we're doing it in a much more conscious way than in the past. Multicommand advanced concept supportability teams are providing logistic support in early phases of Air Force programs. In other words, while you're in the definition phase, you bring in the depot and the logistics commander who are going to have to support the system. When you thrash all that out, make sure you've done a proper logistics support analysis, that you have all the elements laid out, and that you get the training command in. The training command frequently winds up on the short end of the stick. This shows up when you send people to be trained and you find out they don't have the proper equipment to train on. We still don't have enough F-100 engines for engine maintenance training, and we've had F-100 engines in the inventory since the early '70s. You might say that's dumb, and it is. But we didn't do all the prep, and so when engines get short and parts get short, the guys who are in the training business have to suffer. If you do analysis up-front and get the training requirements right, then the trainers will be eating off the same plate with the same priority as the rest of the program. If you don't create that cadre of well-trained people, then that burden flops right on the initial operational commander. We're also requiring earlier program planning and budgeting to ensure that hardware is available for sufficient test and evaluation.

Competition

The sixth initiative is to encourage competition. Right now, for example, we're involved in the major competition for the alternate fighter engine.* We started this 7 years ago, and it has become known as the "great engine war." This is a unique thing we've done, to literally go out and tell a major engine builder that he isn't entitled to all the rest of the contracts to the end of time, and to support the other contractor. It isn't that we think the other supplier is superior. It's just that we have to keep them both in a competitive mode.

e've always had competition in the development phase of our major programs. What we need, though, is competition later in the acquisition cycle. To that end, we're encouraging second sourcing to a great extent. We want to get more competiton in system production and follow-on contracts. We now have a second-source contractor on the imaging infrared Maverick air-to-surface missile. And we're working to get second source on more programs. As a matter of fact, we also have a second source on the Advanced Medium Range Air-to-Air Missile (AMRAAM), and it hasn't gone through development flight testing yet But we made those decisions deliberately; we took that part of the money out of the budget; we funded the prime in order to ensure that he had a responsibility to flow the technical data; and we're going to make those things pay off. Once we pick the winner, and you're talking about building 60,000 missiles, it is certainly in our best interest over 6 or 7 years of those buys to make sure that there's an active competition involved.

Spares Procurement

We simply need more competition. We need to get it across-the-board. Our problems with spares procurement bear this out. Many of these problems were caused by lack of competition. In October, the Air Force Management Analysis Group finished a 4-month study of spare-parts acquisition. One of its key recommendations was to increase competition. To that end we're enlarging and strengthening the competitive advocate program. We've also set competition goals for each of our commands and tasked them to prepare plans to increase competition for all acquisition programs.

A big key to improving the way the Air Force procures spares is manpower. When you get to the bottom of the story, you find that over the past 5 or 6 years, civilian workload have grown much more than civilian manpower. This is especially true in the Air Force Logistics Command, which has most of our civilians. And the people who have been hurt the most are contracting officers, procurement personnel, and cost estimators—all people who are necessary to get the job done in the purchasing of replenishment spares. In response to this we've had to concentrate on the high-value items—the 30 percent of the spares that represent 80 percent of the dollars. We look very closely at these high-dollar items. But in this process we lose the ability to scrutinize the small items, like a small wrench or a plastic stool cap. This problem is directly related to our cutback in people. And there's no relief in sight. We're funding out of our hide an additional 1,000 spaces in 1984 to get back on track, and we've budgeted for another 2,000 during FY 85-86 to do the same thing. It is essential that we use our human resources this way. You can't simply keep loading more contract actions on fewer and fewer people.

Warranties

One trend you should be aware of is the increasing involvement of Congress in all programs. In the fiscal 1984 Appropriations Bill, for example, Congress has required the use of warranties in all of our weapon acquisitions production contracts. The prime contractor must provide a written guarantee that his weapon system or component will meet the government's performance requirements and that he will repair or replace, at his expense, those components that fail to perform. That sounds just fine and generally it is. But like everything else, warranties cost money. What do you think the reaction would be if the Army or the Air Force said to a contractor, "We want you to build us a 1-megawatt space laser and then guarantee its performance." Even if he could figure out how to price that warranty, we wouldn't be able to pay for it. Warranties may not be worth their cost, and we must look at them very carefully. In fact, it can sometimes cost more to test, administer, and validate the conditions of the warranty than the guarantee itself is worth. We could have a big

* *Editor's note:* Since General Skantze spoke the Air Force announced the decision to split the engine buy between Pratt & Whitney and General Electric

test program for 100 aircraft engines, for example. We might find ourselves spending $100 million to validate a warranty that may have cost us $25 million. So, reasonableness and common sense must prevail.

The concept of warranties is a familiar one. You deal with it when you buy a new household appliance or a new car. You even have a choice to make. Do you want the optional warranties they offer you? Will they save you money, or are you better off taking care of the problems yourself as they arise? You may look at your experience and say, "Well, I'm probably better off buying the parts and making any necessary repairs myself." So everyone makes decisions, and you make them based on common sense. DOD is going to ask the same questions and make the same decisions that you do as a consumer. Of course, in our case if we decline a warranty, the Secretary of Defense will have to certify that it is either not in the interest of national defense or not cost-effective.

Responsibility

While others will testify on the Hill about your programs, you will be the ones with the hands-on management authority and responsibility. The point I made to you earlier I restate: It doesn't matter what command, what agency, is responsible for budgeting or for buying the piece of equipment that supports your weapon system. You must be sure you're involved. It isn't going to do your service any good on the initial operational capability date for you to say, "Yes, I know that piece of training equipment isn't here, but that wasn't my responsibility. That was his in the umpty-ump command." That isn't going to help your service one bit. You must be the one who is fully involved and fully responsible. You must involve those other guys who are doing things for you, and you get your boss to involve his boss so that when you come up for program review there's a broad sensitivity to all the things that need to be done. If you're going to be a successful program manager, you cannot restrict your vision in terms of what your responsibilities are. You are totally responsible for everything in that program. And that hardware has to be supportable, operable, and useable. If you think any narrower than that you're going to miss the ball somewhere—I'll guarantee it.

Avoid the Big Mistakes

Each of you, obviously, needs to be knowledgeable on a wide range of disciplines to keep your programs going. The curriculum here at DSMC is going to give you some well-known tools you can use to become good program managers. For those with extensive program management backgrounds, it will serve to "bring it all together" and it will update you on the trends, issues, and future problems.

For those new to the field, it will enable you to hit the ground running. Almost 100 years ago, Otto von Bismarck said, "Fools you are to say you learn by experience. I prefer to profit by others' mistakes to avoid the price of my own." This quote is very appropriate to the process of program management. In the systems acquisition business, it's too expensive to learn through mistakes on the job. We just can't afford it.

I'm reminded of Major General French. I was his aide when I came back from Korea about 30 years ago. One of his wing commanders had a very good pilot land gear-up. General French had a policy that in a case like this the wing commander had to come in with the safety officer and describe what happened and what procedures were missed. I remember this wing commander made an impassioned speech about what a great guy this pilot was, and it was his first mistake, and we ought to let him off the hook. General French heard him out. Then he said, "Colonel, I am touched by your advocacy and by your reasoning. If I had my druthers, I would entitle every pilot in the Air Force to one gear-up landing. *But you know we can't afford it.*" It's the same way in program management. Although you'll make mistakes, to be sure, you want them to be small ones.

Be Creative

Some of you, when you leave here, will go to work on very large, expensive programs with dozens, maybe hundreds, of people involved. Others will work on small programs where you may be dual-hatted as the leader and the follower, sort of a one-man office. In either case, be aggressive, be creative. As Thomas Edison said 65 years ago, "There's a better way to do it—find it."

Possibly most important, keep a broad perspective. What is good for your program isn't necessarily the best thing for your service. Perhaps the greatest unheralded ability of the program manager is to recognize a dead horse when he sees one and to bury it with the least ceremony. That is a rare trait.

Tell It Straight

Here's another bit of advice. With the bad press we've had in the acquisition business, some of it deserved, we need to regain and retain the trust of the American people. In that respect I would make two other points. When you go to the Hill, and you'll get your opportunities to go to the Hill, don't try to finesse the Congress. Lay out the facts. If your program has fallen behind schedule, tell them why. It doesn't matter that you were there last year and told them that this supersonic widget was just coming along great and that everything was coming along on schedule and within cost. Six months later you may suddenly have found yourself holding a handful of ashes. And if that happens, you will have to go over and testify that you are going to slip your program or do something different, or correct the technical risk. Make sure you see the staffers before you see the chairman, and tell them what's happening. Don't let some-

body surface it for you. Just put the facts on the table: don't try to finesse and don't try to alibi. They're smart. Most of the congressmen and their staffers have been there long enough that there isn't any disaster you can tell them about that they haven't seen or heard, in spades. Congressional staffs and chairmen have come to appreciate the fact that disasters are not necessarily uncommon, but they appreciate honest people who say, "Here's the way it is."

Delegate

One of the biggest challenges you're going to have as a program manager is to decide what kind of information you need to see and how often. Everybody wants your attention. Every guy who works for you thinks his aspect is the most important. If you let him, he's going to dump everything on you. It is in the nature of this business that when people can get you to make the decisions, they will dump them on you and you'll suddenly find that the pile of paper in your in-basket has just gone to the ceiling. The key is to tell yourself and your people that you're delegating the responsibilities. For example, say to the chief engineer, "You're the chief engineer. I want to look at the decisions you've made, but you make them. Just come and tell me what you recommend." Do the same with finance, test, contracts, the whole works. The key is to make sure you get the right kind of information so that you can detect the problems when they're acorn size.

Integrity

We've heard a lot recently about acquisition initiatives. Obviously, we can propose all the acquisition initiatives in the world. We can implement them and educate people with all the skills necessary to make acquisition programs function. But none of it will do any good unless the personal integrity of our program managers is unquestioned. Ensuring that America gets its money's worth depends on the integrity of the individual. It goes back to that comment I made on dealing with Congress or OSD or any of the staffers. If you've built a reputation of integrity, then you can have problems and people will understand them and work with you. Once you get that reputation of integrity and credibility, you have gone a long way toward establishing yourself as competent and credible.

Many of our problems in spares acquisition would never have surfaced but for people like you, men and women of the armed forces, both military and civilian, who recognized a problem and said, "Hold on, this is dumb," or "It's wrong." Today, we're spending 40 cents each for plastic caps for navigator stools that cost us $1,000 each until a sergeant pointed out the problem. Many times, people are led to believe that the system can't tolerate bad news. This is dead wrong. Without people who have the integrity and courage to tell the bad news, leadership can't correct the many problems that need to be set right.

Diversify

Finally, I'd like to close with something I feel very strongly about: that program management is too important to be left to engineers, too important to be left to financial comptrollers, too important to be left to contracting officers, too important to be left to logisticians. What I'm really telling you is that a successful program manager, while he may have his major experience in one of those functions, learns the *other* functions to the extent he needs to understand them to execute his program. Will Rogers said, "Everybody is ignorant, only on different subjects." The program manager can't afford to be ignorant on any subject.

I never had a bit of formal training in contract management, in financial control, or in logistics. But I realized I had to learn it, and I guarantee that if you talk to any successful program manager, you will find that whatever his basic function or background, he has picked up some of the rest. I know contracting officers who became program managers and then developed an inherent sense of engineering judgment. This meant they could ask very simple questions like, "What's the next important *milestone in the development?*" When they got that answer, they could follow up with, "How much confidence do you have that you can meet that? What's the major thing that worries you about meeting it? And they could go [illegible] series of questions like that without having an engineering degree.

hatever your functional background, you need to use it in conjunction with the other program management functions. You can't afford to take financial control, but just because you have a colonel or a captain who is your financial controller, you don't give control to him and say, "Go do it." What you must do is learn how to read that cost-performance report, and then you have to start asking questions. Once you show that you know what you're doing and begin to ask the right questions, you'll be surprised at the effect it will have. You will find that this will even reach the contractor. You will find him putting emphasis on the same areas you emphasize. For example, if you go to his plant once or twice a year or whatever, and you never say to him, "Let's spend an hour going over the cost-performance report and then you give me a briefing," I'll guarantee he's not going to worry about cost and performance. That contractor will let his bean counters worry about it, and you won't know what is happening until you get into real trouble. The message I want to leave is that you have to develop skills across-the-board. Every successful program manager has learned how to do that and has learned how to exercise his understanding of other professional functions.

The Challenge

When you leave here in 20 weeks, you will be managing the weapon system programs our services will need to defend our nation and our national interests in the next century. Get everything you can out of this school, because we need the best managers we can get.

You have a great challenge before you, but I can assure you after 35 years' experience that there is nothing as exciting, as challenging, and as frightening as the acquisition business. If nothing else, you are going to be terribly stimulated by it for the rest of your careers. ■

Controversy Over

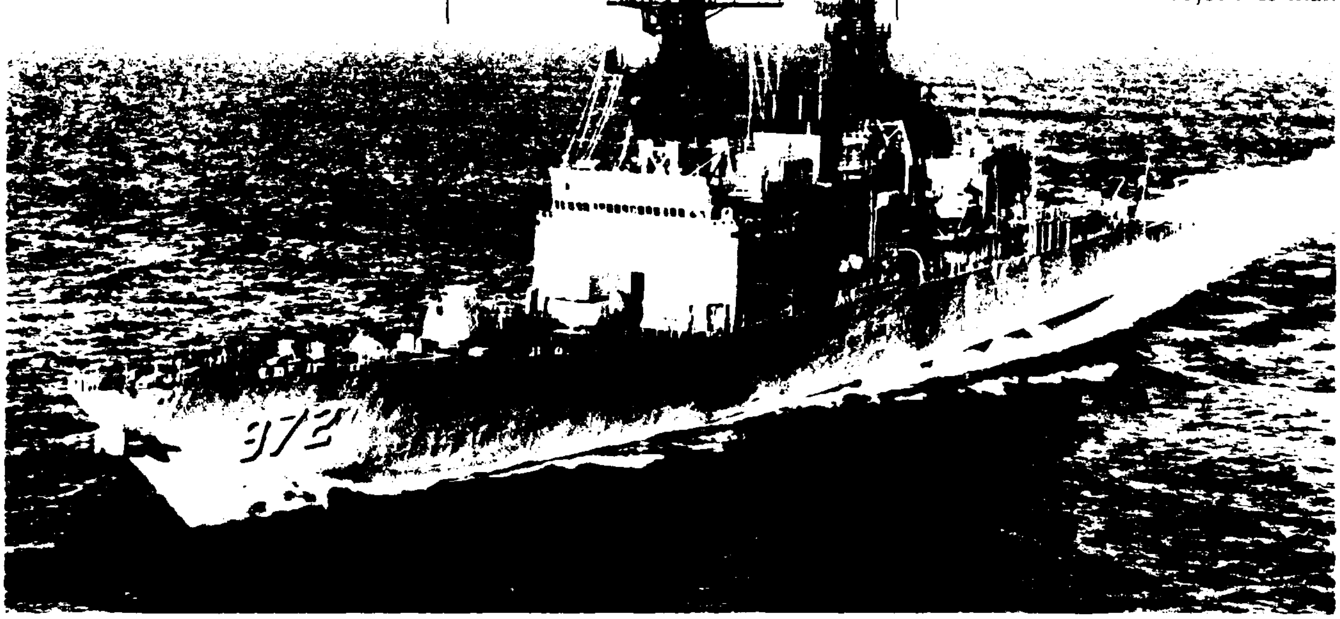
An Analysis of Firm-Fixed-Price vs. Cost-Plus-Award-Fee Contracts for DD 963 Class Ship Regular Overhauls

Edward J. Downing, Joseph Grosson, Leonard Schwartz, and Carl Weaver

he evolution of the government procurement process has been significantly influenced by the increasing variety of needs of federal departments. As government roles and missions have expanded and equipment and technology have become more complex, new contract types have evolved for use in obtaining systems, materials, and services. In addition, variations in contract types have been developed to accommodate specific government requirements for the life-cycle support of a military system. Each type of contract differs from the others in its essential elements, application, limitations, and suitability.

Contract types used by the Department of Defense generally differ in the share of risk assumed by the government and the contractor, as well as in the type and amount of incentive offered to the contractor for achieving specified goals. At one end of the spectrum is the firm-fixed-price (FFP) contract where all financial risks are assumed by the contractor. The Navy's legislatively preferred contracting methodology is to use formal advertising (invitation for bids—IFB) resulting in an FFP contract. This is a simple and rigid process that allows, when competition exists, the procurement of a well-defined item or service for the lowest reasonable price. This process is preferred by the government wherever feasible and is effective when there is no ambiguity in describing the product or service desired. Lowest overall price to the government, including "foreseeable" cost, such as transportation co· government personnel travel s, etc., is the basic criterion for ·ction, with the understanding tha ·e proposed contractor is "resp ole" and was "responsive" to tl ·:able IFB.

At the other en. . the spectrum are cost-reimbursement contracts where the majority of financial risk is essentially assumed by the government. A cost-plus-award-fee (CPAF) contract is a cost-reimbursement type that uses a subjectively determined monetary award to reward superior contractor performance. Once this contract type is selected for use, the contract itself may be tailored to fit the specific acquisition. Tailoring is a healthy process, because it allows the government and the contractor to balance a number of objectives. Researchers have found, for instance, that firms have more objectives than



just profit. These include items such as a good product, work force development, capacity utilization, and long-term relationships with government agencies.[1]

Controversy has developed recently concerning the best type of contract to use for the overhaul of Navy ships in private shipyards. In March of 1982, additional facts and opinion with respect to contract types were added to the debate with the release of a U.S. General Accounting Office (GAO) report entitled "Actions Needed to Reduce Schedule Slippage and Cost Growth on Contracts for Navy Ship Overhauls." In this critical report, the GAO charged that the Navy was using contracting techniques that were not well suited to achieve quality overhauls on time and at minimum cost.[2] Specifically, the GAO was critical of the suitability of the Navy's use of FFP contracts (actually fixed-price orders under master ship repair contracts). The GAO advocated use of a negotiated contract (such as CPAF) for this purpose, since the uncertainty of the total work package for ship regular overhauls supports a need for a flexible contract that provides incentives for superior performance.

ur purpose here is to discuss the major issues surrounding the controversy between the DOD preferred fixed-price contracting methodology and an emerging methodology centered around the reimbursement of costs with incentives for good contractor performance in cost, schedule, and technical areas.

The following discussion of contracting methodologies is limited to formal advertising under master ship repair contracts, leading to an FFP deliver order and a negotiation process leading, in turn, to a CPAF contract. We will examine cost, schedule, and quality of work implications of CPAF vs. FFP awards with respect to the unique characteristics of DD 963 class ship regular overhauls (ROHs). First, we will examine the two contract methodologies in general; second, we will review their applicability to Navy ships undergoing ROH in private shipyards; and third, we will look at their specific applicability to the DD 963 class ROH program.

Comparison of FFP and CPAF Contracts

Firm-fixed-price and cost-plus-award fee contracts differ in several major aspects. The FFP contract makes maximum use of competition to achieve the lowest price by having contractors bid a price based on the statement of work written by the government. Since this type of contract places maximum financial risk on the contractor by making him fully responsible for cost, the government must completely describe the work to be done. The CPAF contract, on the other hand, is designed to provide some incentives to a contractor in situations where no finite description of the product (performance) is possible, at least not to the degree necessary for the FFP contract. To further compare FFP and CPAF contracts, three general areas of difference should be considered: application and essential elements, limitations, and suitability.

Firm-Fixed-Price Contracts

APPLICATION AND ESSENTIAL ELEMENTS

The Defense Acquisition Regulation (DAR) states that "the FFP is suitable for use in procurements when reasonably definite design or performance specifications are available and whenever fair and reasonable prices can be established at the outset. . . ."[3] In addition to the general application guidance, the DAR requires that several specific conditions be met before the FFP contract may be used. These are summarized below.[4]

—There must be adequate competition.

—There must have been prior purchase experience of the same or similar supplies or services under competitive conditions.

—Valid cost or pricing data must be available to permit realistic estimates of the proposed costs.

—Possible uncertainties in contract performance must be identified and costed.

LIMITATIONS

ssuming the contract is not changed during the contract period, price is not subject to adjustment regardless of performance costs. The contractor must be willing to accept the contract at a level that causes him to take 100 percent of the financial risk. This makes the FFP contract most attractive to the government. It results in a stable, known cost; it has very low administrative burden; and it places great emphasis on lowest cost.

SUITABILITY

Firm-fixed-price contracts are suitable for use when the government is purchasing standard or modified commercial items, military items for which reasonable prices can be established, and services where performance specifications are well-defined. In order to take full advantage of the provisions of an FFP contract, no new work should be initiated after contract award. This would diminish the value of the FFP contract.

■ *Mr. Downing is a Principal Staff Member at Advanced Technology, Inc., and a graduate of PMC 77-2.*

Mr. Grosson is Director of Business Development at Lockheed Marine Systems Group. He was formerly Project Manager, Destroyer Ship Acquisition Project, Naval Sea Systems Command, and Executive Director for Acquisition, HQ Naval Material Command.

Mr. Schwartz is Director of Plans, Programs, and Business Financial Management, Gas Turbine Surface Combatant Ship Logistic Division, Naval Sea Systems Command.

Mr. Weaver is a Program Director at Advanced Technology, Inc., and a graduate of PMC 76-2. ■

ADVANTAGES

Significant advantages of FFP contracts include the following:

—The contractor essentially assumes all financial risk, although he can apply for relief under Public Law 85-804 or go bankrupt to shift the financial burden to the government.

—The government knows the cost at the outset of the contract, and this cost is fixed (assuming the contract is not changed later).

—The government cost to administer the contract is minimized.

DISADVANTAGE

The effectiveness of an FFP contract is highly dependent on the ability of the government to define the work to be done in advance of contract award. Since the contractor gains one dollar of profit for each dollar he saves, his incentive is to reduce his costs by doing only the minimum work required by the contract. Unfortunately, experience has shown that ship overhauls are highly individualized and not conducive to standardized work-package identification. The specific disadvantages of FFP contracts, then, include the following:

—The contractor's objective is usually to maximize his profit by cutting his costs to a minimum. There is the possibility of inferior quality or a schedule delay.

—If the government changes the contract after it is awarded, the contractor has a strong incentive to take advantage of his sole-source position and negotiate the highest possible price.

—Reasonably complete specifications must be available to define the work to be done. Consequently, an FFP contract cannot be used for multiship or multiyear overhaul contracts where work packages for follow-on ships cannot be defined at contract award.

—Changing an FFP contract may be a more time-consuming process than changing a cost-type contract.

CPAF Contracts

The GAO believes that the Navy trend toward use of requests for proposals (RFPs) is a move in the right direction.' The RFP process can lead to cost-type contracts, the use of incentives in addition to cost, an increase in visibility of costs, and improved communication between the contractor and the government.

APPLICATION AND ESSENTIAL ELEMENTS

Cost-Plus-Award-Fee contracts follow DOD policy by using profit to stimulate efficient contract performance.[6] When performance by the contractor is not susceptible to finite measurement and contract changes are expected, a CPAF contract provides incentives for good performance. Award fee may be earned by the contractor as determined unilaterally by a government fee determining officer (FDO). The fee award is based upon the recommendations of an Award Fee Evaluation Board (AFEB). Two separate fee pools will be established in the contract: an award fee and a base (fixed) fee. The base fee may not exceed 3 percent of the contract estimated cost and does not change with contractor performance. The award fee, which is usually larger than the base fee, cannot exceed certain regulatory limits. In general, the amount of award fee earned is in direct relation to the contractor's performance in compliance with contract provisions, quality of work, timeliness, ingenuity, and cost effectiveness. Evaluations of the contractor's performance are preplanned and conducted at stated times during the contract period.

ADVANTAGES

A CPAF contract is best suited to a situation in which there is uncertainty with respect to the scope of work, and the degree of success of the project must be measured subjectively. Advantages of CPAF contracts include the following:

—Where firm, graduated, objective performance criteria cannot be set before work begins, a CPAF contract provides for subjective evaluation.

—A CPAF contract is flexible. Emphasis can be shifted from one area to another during the contract period. This allows for contingency planning and corrective action as required.[7]

—Communication between the government and the contractor is greatly improved because there is a closer working relationship than with other contract types. Furthermore, research has shown that contractor performance improves with increasing top-level government-contractor interaction.[8]

—By offering an award fee for performance to schedule, the CPAF contract encourages on-time start of follow ships.

—Recent studies have shown that contractors perceive award fees as effective.[9] One result is that the responsiveness of the contractor to government goals is increased. The contractor program manager then has extra leverage over corporate resources.[10] This is especially important when one job is competing with others for contractor attention and resources.

—The CPAF contract allows award of multiship overhaul contracts for which work packages will experience significant change.

—Since the government's determination of the amount of award fee earned by the contractor is not subject to the disputes clause, the chance for a timely closing of the contract is increased.

DISADVANTAGES

CPAF contract has some disadvantages to both the contractor and the government. These disadvantages include the fact that a CPAF contract is costlier to administer than on FFP contract, and that the government requires the contractor to have an adequate cost performance measurement and reporting system.

CAUTIONS

There are some additional points that must be understood when considering a CPAF contract; however, with proper planning, these need not present a problem. They include the following:

—It takes time for the government to verify contract costs and predict the extent of technical problems. Early apparent success can be shown to be unfounded when the final figures are compiled. This recently has been overcome to some extent by delaying the end of the final award-fee period until the end of the warranty period, or 60 days after the ship is returned to the Navy.

—Responsibility for cost may be difficult to evaluate. In general, the amount of the award fee should cor-

respond to the degree of improvement or program degradation during the evaluation period, but it should also be based on other aspects such as realism in change proposals, disposal of surplus material, and costs out of the contractor's direct control (acts of God, shipyard overhead rates, G&A rates, government impact on cost, etc.).[11]

—The award-fee performance areas must be carefully structured and monitored to keep the contractor's effort balanced. If the contractor anticipates that he will be unable to win very much award fee in one area, he may choose to ignore it and concentrate on those areas where he still has a chance.[12] For this reason, preset objective criteria generally detract from the inherent flexibility of a CPAF contract and should be used with caution.

Ship Regular Overhaul Program

Navy ships undergoing regular overhauls (ROHs) have been over budget and behind schedule. While there is no single reason for this, some explanation may be found in the traditional use of formal advertising under master ship repair contracts and FFP awards.

The Navy ROH program is highly fragmented and complex to manage. Funding authority is divided between the Type Commander (TYCOM), who is responsible for repairs performed during ROH, the Naval Sea Systems Command (NAVSEA), which is responsible for ship alterations. The situation is made more difficult because a large part of the work to be done during the overhaul is not definitized until after the contract is awarded and the overhaul is under way. It is also difficult to anticipate the new or changed work that will be required during an overhaul. Work packages must be prepared months in advance of the start of work. Operational requirements may even require that the shipcheck (necessary to develop the work package) be performed on a comparable sister ship, rather than on the ship to be overhauled.[13] A 1980 Navy study of destroyers found that only about 50 percent of the overhaul work recurs from ship to ship. The GAO concluded in 1982 that the most significant problem causing cost growth appeared to be the development of work packages covering repairs and maintenance.[14]

nother problem encountered by t Navy ROH program is the long delay to authorize changes or new work. The GAO reported that weeks are often required before work can begin.[15] This, of course, can delay completion of the overhaul and cause inefficient use of contractor resources. The delay is caused by Navy-contractor negotiation on price and scope of work. Agreement is usually easier to reach on CPAF than FFP contracts because, on CPAF contracts, contractor costs will be covered; therefore, the contractor will not have to include as large a contingency fund in his price.

These and other problems have led to continuing animosity between the Navy and civilian ship repair contractors. The GAO blames formally advertised contracts for contributing to this adversary relationship and calls upon the Navy to use contracting methods that foster a more cooperative relationship with the contractor.

Effective Ship Overhaul Contracting Methodologies

GAO Recommended Approach

Traditionally, the Navy has used formal advertising, under master ship repair contract, leading to an FFP award to obtain the services of private yards for ship regular overhauls. One significant difficulty in this approach is that the resulting FFP contract requires that needed repairs, alterations, and maintenance be identified in advance and be described in great detail. But the complexity of the ship overhaul process is not fully compatible with the definitive work description required for FFP contracts. Consequently, when FFP contracting is used for overhauls, some cost growth can be expected as new work or changed work is initiated. The cost-growth phenomenon associated with FFP contracting may be further aggravated by the selection of unrealistically low bidders. The GAO warned that the use of FFP awards for ship ROHs may be causing excessive amounts to be paid to contractors who submit unrealistically low bids, in expectation of making up their costs and profits on contract changes. As a result, the Navy may pay more and get a less effective overhaul.[16]

he GAO reports that two elements are necessary to improve overhaul effectiveness in a competititive environment.[17] First, the government must involve the contractor in the overhaul planning process. This involvement must draw upon contractor expertise, foster an early agreement on the details of the work, and establish a cooperative atmosphere. Second, the government must provide the contractor with an incentive for good performance. Use of a negotiation process leading to a CPAF contract provides the elements suggested in the GAO approach. The CPAF contract provides incentive that can reduce schedule slippage and cost growth in ship ROHs.

Naval Audit Service Recommended Approach

The Naval Audit Service (NAS), in a 1979 report of a periodic audit of the Supervisor of Shipbuilding, Conversion, and Repair (SUPSHIP), Seattle, was critical of supplemental work authorizations that substantially expanded shipwork originally awarded by FFP job orders.[18] The NAS cited the Chief of Naval Operations' policy requiring deferral of non-critical new work found during the overhaul until the next regularly scheduled overhaul so that the required competition could be obtained. The NAS further maintained that the Navy should either ensure compliance with the

policy regarding the deferral of supplemental work, or rescind the policy.

Other Considerations

Selecting an effective contracting methodology for ship ROHs is more complex than the generalized GAO and NAS recommended approaches just described. Two additional elements must be considered. First, there must be an understanding of the basic differences between FFP and CPAF contracts. Second, there must be an understanding of the ship ROH environment in order to determine which contracting methodology should be applied.

Navy ROH Contracting Policy

Based on the use of formal advertising under master ship repair contracts and FFP awards, there are certain safeguards the Navy has built into its ROH contracting policies. In order to be eligible to be awarded an overhaul contract, a contractor must hold a master ship repair (MSR) contract. This entails an inspection of his facilities to determine his capability to perform work of an "unspecified nature." The contractor who submits the low bid for an overhaul is then subject to a pre-award inspection designed to determine his capability to perform the specific work required by the contract.[19]

n spite of these precautions, it has proved to be legally difficult to disqualify marginal contractors on the basis of their apparent lack of capability. The Small Business Administration has, in the past, overturned initial Navy decisions to disqualify small business contractors by issuing a Certificate of Competency. On the other hand, the use of negotiation and cost-type contracts permits evaluation of proposals and selection of a contractor based on factors other than cost alone, thereby reducing the likelihood that a marginal contractor will be awarded the contract.

DD 963 Class ROH

The DD 963 class ships are powered by gas turbine engines and incorporate multiple modern weapon systems. The overhaul of these ships is much more complex than the overhaul of either fast frigates or conventional steam-driven destroyers. The newness and complexity of the DD 963 class ships add a significant number of changes to ROH work packages and modifications to the ROH contract. The certainty of this unstable situation, especially with early overhauls, led to the use of CPAF contracts for the DD 963 class ships presently under ROH contract.

The DD 963 class overhaul contracts are structured to take maximum advantage of the flexibility of a CPAF type contract, while controlling the contractor's effort through the use of strong award-fee incentives. The overhaul is divided into three or more periods, with the contractor rated during each period in the areas of technical/management, schedule, and cost. Before the start of each period, the fee determining officer sets weighting factors for each evaluation area. This way, emphasis can be shifted from one area to another with some reasonable assurance that the attention of the contractor will follow. This ability to guide the contractor's attention has been strengthened by incorporating into some of the contracts a provision that permits an 80-percent carry-over of lost award fee from one evaluation period to the next (except for the last period when the government retains the lost award fee). This increases the incentive for the contractor to improve his future performance while still losing some fee for less-than-excellent past performance.

Careful determination is made of the fee awarded to the contractor. The Award Fee Evaluation Board recommends a level of award fee for each period based on the member's own knowledge of contractor performance, contractor reports, and reports by monitors who follow, in detail, the contractor's progress. After the Board's recommendation is submitted to the fee determining officer, the contractor has an opportunity to submit comments concerning performance during the period. The decision of the fee determining officer, however, is final and not subject to dispute by the contractor.

he contract record of the DD 963 ROH program has been excellent to date in comparison with comparable FFP overhaul contract programs, especially since two of the DD 963 ships were single-ship overhaul contracts, and two were each the first of multiship overhaul contracts. Follow-on ships of a multiship overhaul contract should have an advantage from both a learning-curve effect resulting from prior experience, and from a more efficient pattern of buying and use of material. First quarter FY 82 to first quarter FY 83 NAVSEA reports to the Chief of Naval Operations on the Program for Improvement of Ship Overhauls contain data reflected in Table I.[20]

Table I shows that the average cost of the DD 963 class ships, as a percentage of the Chief of Naval Operations' notional estimate, is slightly greater than that of other surface ships of mixed types, but is less than fast frigates of less complexity. The 8 percent average early completion time is much better than the average completion of either of the other two groups. These figures are reinforced by data from the 1982 GAO study of 119 surface ships, which reported an average 50 percent cost growth overall, 59 percent for 14 destroyers, and 56 percent for 25 frigates. In comparison, the 50.5 percent cost growth for the DD 963 class ships shown in Table I is less than expected.

Another favorable sign from the still-young DD 963 ROH program is reflected in the cost to overhaul the *USS Radford* (DD 968). The contract award of $11.4 million to Ingalls Shipbuilding Division (ISD) of Litton

	AVG % COST GROWTH*	AVG % EARLY (LATE) COMPLETION TIME**
66 SURFACE SHIPS (FFP)	47.7	(8.9)
7 DD 963 (CPAF)	50.5	8.0
6 FF (FFP)	53.0	1.0

$$*\frac{\text{FINAL CONTRACT COST\#} - \text{AWARD CONTRACT COST\#\#}}{\text{AWARD CONTRACT COST\#\#}} \times 100$$

INCLUDES ACTUAL FEE
INCLUDES POSSIBLE FEE

$$**\frac{\text{ACTUAL DURATION} - \text{CNO NOTIONAL DURATION}}{\text{CNO NOTIONAL DURATION}} \times 100$$

Industries was so far (53 percent) below the government estimate of $24.4 million that the Naval Audit Service recommended that NAVSEA review the contract award with the intent of correcting deficiencies in the proposal evaluation process. It was feared that an unrealistically low bid would lead to extremely high cost growth and an overall high contract cost.[21]. Ultimately, the contractor's estimate proved correct, and the *Radford* overhaul cost growth of 46.5 percent was well below average. Additionally, the overhaul was finished 13.5 percent ahead of the CNO notional duration estimate.

The importance of this early completion and moderate cost growth over a surprisingly low award cost is that it demonstrates that CPAF contracts may be favorably compared with FFP contracts for cost effectiveness of ROH. It would be speculative to analyze the rationale behind the low bid and subsequent cost, but for the purposes of contract-type comparison, it illustrates the ability of a CPAF contract to encourage cost control. In this case, it would appear that Ingalls reacted to competition and a reduction of the risk by completing the overhaul in a timely manner at a low overall cost to the Navy.

Another advantage of the CPAF in this situation is evident in the overhaul award fee scores for initial DD 963 class ship ROHs.[22]

Not only do the scores on completed ships show good overall ratings, but the rising nature of the scores indicates a corporate learning process in which the contractor does an increasingly better job of satisfying the Navy as the contract progresses.[23] The rising score phenomenon is not always apparent, however, and for some of the DD 963 class ships, the scores do not have a rising pattern. Three possible explanations are (1) a changing work force that had to be re-educated during the contract period, (2) a shift of emphasis by the fee determining officer from one grading area to another, with a consequential decline in the contractor's score, or (3) contractor yard workload during different overhaul periods.

Summary

Formal advertising under master ship repair contracts and FFP awards, in which the contractor assumes all the financial risk, are best used when work to be accomplished can be described well enough to avoid major or numerous changes to the contract work package. The Navy ROH program, which has traditionally relied on FFP awards, has been characterized by extremely high cost growth, schedule overruns, and a lack of cooperation between the Navy and the overhaul contractors. The DD 963 class ship is highly complex, and its ROH program is characterized by new and expanded work that is evident only after overhaul has commenced. In this environment, subjective evaluation of the contractor's performance, considering the circumstances, is the fairest basis on which to compensate the contractor with more or less profit.

The greatest disadvantage of CPAF contracts is the time and effort the Navy must put into contract administration. However, in the case of the DD 963 ROH program, the size and complexity of the DD contracts, the history of ROH difficulties on previous programs, and the initial success using CPAF contracts on DD overhauls, justify continued use of CPAF contracts until the risk of major contract changes has been substantially reduced. The use of a fixed-price-award-fee contract should be explored as an intermediate step to a firm-fixed-price contract. Then when a definitive specification package can be ready for competitive award of a DD 963 class ship, a fixed-price type contract should be awarded and the contractor's performance evaluated.

Therefore, the type of contract better able to meet the requirements for the DD 963 class ROH program at this time is the cost plus award fee (CPAF), in which the government knowingly assumes fiscal risk but holds the contractor to high standards by requiring him to place his profit at risk. As implemented by the DD 963 ROH program, this type of contract allows the Navy to exert positive influence during the contract period; it also brings together the Navy and the contractor as a team with a common objective of achieving excellence in cost, technical, and schedule performance by maximizing award-fee allocations.

When this objective has been reached, both team members will have achieved their goals. ■

Notes

1. R. F. Williams, "So What Does the Defense Contractor Really Want?" *Program Manager*, Vol. XII, No. 2, March-April 1983, p. 25.

2. U.S. General Accounting Office, "Actions Needed to Reduce Schedule Slippages and Cost Growth on Contracts for Navy Ship Overhauls," March 17, 1982, p. ii.

3. Defense Acquisition Regulation, *Government Contracts Reporter*, Vol. 3,

Chicago, Ill: Commerce Clearing House Inc. 1981, para. 3-404.2.
4. *Ibid*., para. 3-406.1.
5. GAO, pp. 41-38-37.
6. DAR, para. 3-808.1.
7. G. H. Jenkins, "Decision Criteria for Cost-Plus-Award-Fee Contracts in Major Systems Acquisition," master's thesis, Naval Postgraduate School, Monterey, Calif., March 1979, p.30.
8. Major J. V. Brown, USAF, "The Award Fee Incentive: Management Considerations Regarding Its Application to Research and Development Contracts," Defense Systems Management College, Fort Belvoir, Va., November 1976, p. 20.
9. Williams, p. 28
10. R. G. Hunt, "Contractor Responses to Award Fee Contracts," *National Contract Management Journal*, Winter 1982, pp. 84-85.
11. Naval Sea Systems Command, message to Commander in Chief, Atlantic Fleet, "Award Fee Evaluations, Further Guidance for DD 963 ROHs," 271841Z, May 1983.
12. *Ibid*.
13. J. F. Grosson, PMS 389 paper, "Use of Cost Plus Award Fee (CPAF) Contract for Nine-Ship (DD 963 Class) Regular Overhaul Package," March 17, 1983, para. 2.
14. GAO, pp. 8-9
15. *Ibid*., p. 26
16. *Ibid*., pp. 8, 33
17. *Ibid*., pp. 34-35.
18. Naval Audit Report A41441 Supervisor of Shipbuilding, Conversion, and Repair, Seattle, Wash.; Section B, Audit Findings and Recommendations, Management Responses, and NAVAUDSVWEST Comments, Procurement, 1, "Shipwork to Completion," May '0, 1979, p. 3.
19. Ship Repair Contracting Manual (Repair Manual), Naval Sea Systems Command, 1979 Ed., para. 7-4, 11 1(a) and para. 7-4.11 1(b).
20. Naval Sea Systems Command, Letters to Chief of Naval Operations, "Program for Improvement of Ship Overhauls," First Quarter FY 1982, dated April 13, 1982; Second Quarter, FY 1982, dated June 3, 1982; Third Quarter, FY 1982, dated August 2, 1982; Fourth Quarter, FY 1982, dated November 23, 1982; First Quarter FY 1983, dated February 17, 1982.
21. Naval Audit Report A41441 Supervisor of Shipbuilding, Conversion, and Repair, Pascagoula, Miss. Section B, Audit Findings and Recommendations, Management Responses and NAVAUDSVCSE Comments, Major Procurement and Related Contract Administration, "The Evaluation of Contractor Cost Proposals for Overhaul of the DD 968 Is Questionable," July 16, 1982, p. 6.
22. Naval Sea Systems Command (PMS 389), Letter to Chief of Naval Material (NAVMAT 02), "Use of Award Fee on Contracts for Private Sector Regular Overhaul (ROH) of DD-963 Class Ships," undated.
23. J. R. Runkle, and G. D. Schmidt, "An Analysis of Government/Contractor Interaction as a Motivator of Contractor Performance" thesis presented to faculty, School of Systems and Logistics, Air Force Institute of Technology, Air University, August 1975, cited by Brown, 1976., p. 53.

and the Management Challenge

David D. Acker

Through the years, robots of one kind or another have been portrayed as either heroes or villains in countless stories, movies, and television programs. The mass media have introduced us to the likes of "HAL" of "2001: A Space Odyssey," "Robot" of "Lost in Space," "Robbie" of "Forbidden Planet," and, more recently, "C3PO" and "R2D2" of "Star Wars." The one thing all these robots, and myriad others of television and movie fame, have in common is their similarity to human beings, even to the extent of having the capacity for emotion. The popular imagination has been further fueled by the recent introduction of two actual robots, *Hero I* and *Scorpion*.

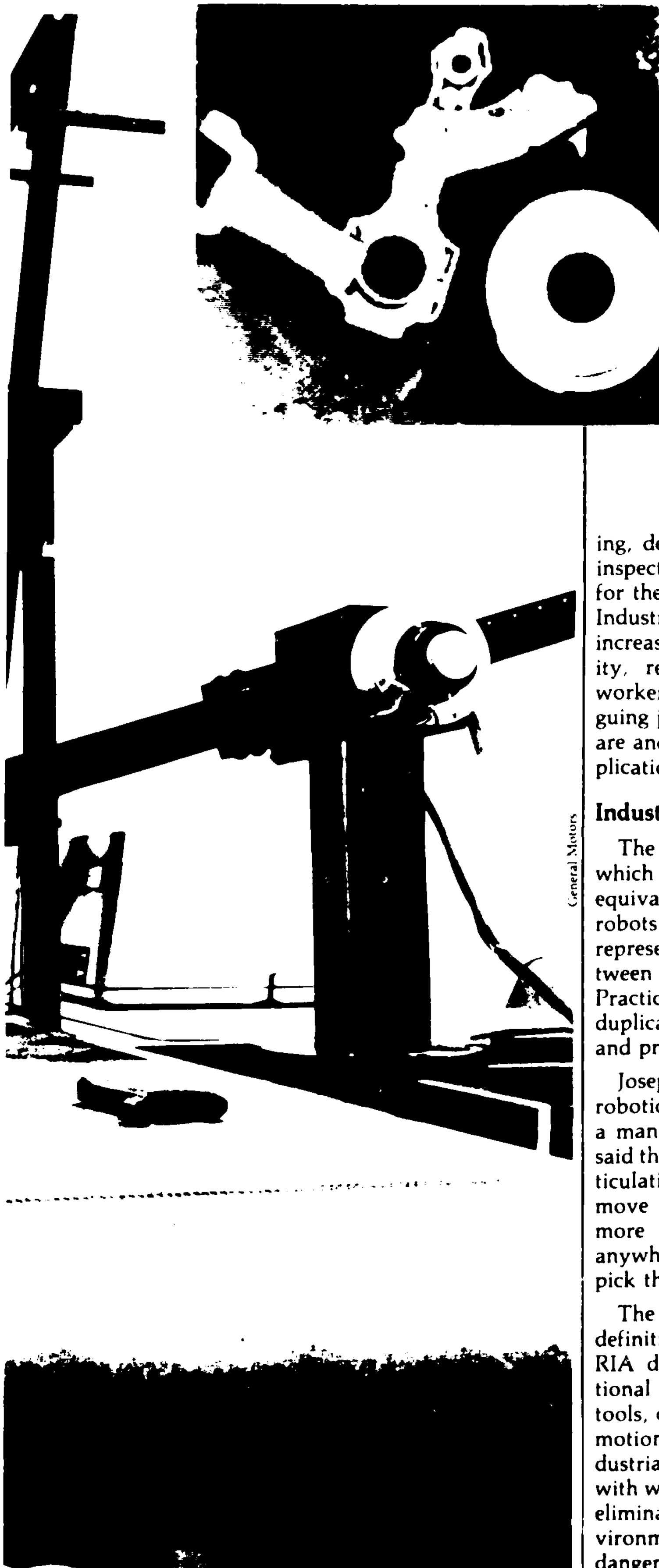
Hero I, a product of Heathkit, is a completely self-contained robot that moves on wheels. Controlled by an on-board, programmable computer, Hero I has five axes of motion, electronic sensors to detect sound, light, and motion, and a voice synthesizer. The robot can be programmed to perform such basic tasks as picking up small objects.

Scorpion is a small, sophisticated robot with an on-board computer. Designed for serious computer hobbyists by Rhino Robots, Inc., it has a speaker, two eyes, two ground tracks, and the capability to move in any direction at 99 different speeds. The robot can follow instructions and answer questions posed by a host computer.

These robots, and others like them, are interesting—and possibly even amusing—but they represent less than 1 percent of all robots in existence. It will no doubt disappoint science fiction fans to learn that, in fact, the state of the art in robotics falls far short of the popular imagination. Compared to the popular image of robots (walking, talking, mechanical humanoids with superhuman strength and skills), present-day industrial robots seem rather pedestrian.

Industrial Robots

Industrial robots, for the most part, perform simple, repetitive motions with some degree of precision. They perform such tasks as welding, forging, material handling, machine loading/unloading, palletizing, machining, grind-



General Motors

ing, deburring, polishing, spraying, dipping, assembling, inspecting, and packaging. A limited number can "think" for themselves. In a few cases, they use artificial vision.[1] Industrial robots have the potential to benefit all of us by increasing productivity, providing manufacturing flexibility, reducing manufacturing costs, and by replacing workers in hot, dirty, hazardous, monotonous, and fatiguing jobs. The rest of this article is focused on where we are and where we are headed in the development and application of these robots.

Industrial Robots Defined

The term "robot" comes from the Czech word *robota*, which means servitude or drudgery, and the Old Slavic equivalent *rabota* meaning work. According to Webster, robots are "heartless automations." In a factory, robots represent off-the-shelf automation. They fill the gap between special purpose automation and human endeavor. Practically speaking, they are machines that are capable of duplicating human skills and flexibility with both accuracy and precision.

Joseph F. Engelberger, who is often called the father of robotics, has defined a robot as a machine that performs in a manner ordinarily ascribed to a human being. He has said that a robot ought to have an arm with at least six "articulations" (joints). A robot needs three articulations to move the "wrist" member anywhere in space, and three more articulations to aim the "hand" (end-effector) anywhere in space. In addition, a robot should be able to pick things up and interlock with other machines.

The Robot Institute of America (RIA) has developed a definition that it hopes will become the industry standard. RIA defines a robot as "a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks." An industrial robot can control and synchronize the equipment with which it performs. With this kind of capability, it can eliminate the need for people to work in the immediate environment—an environment that may be dirty, dull, or dangerous.

Robot Components

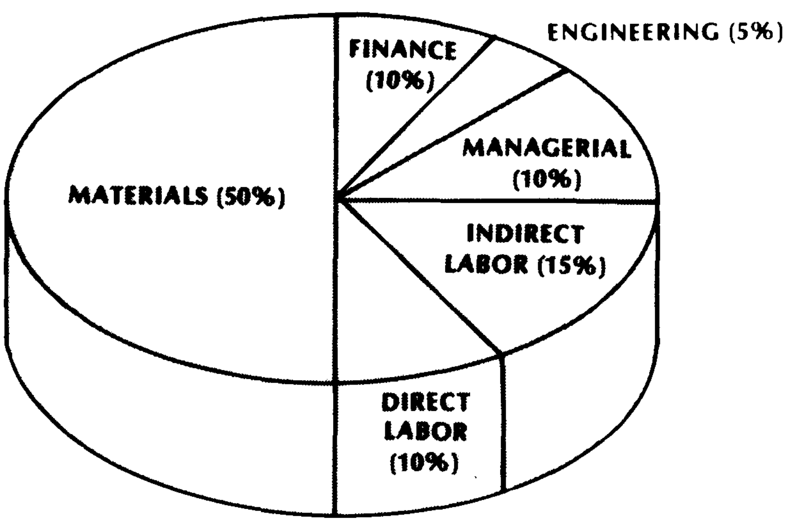
An industrial robot generally consists of three basic components—a manipulator, a controller, and a power supply—and a piece of auxilliary equipment known as an end-effector.

The manipulator consists of two primary mechanical sections, the base and the attached appendage. The base is usually stationary, although in some applications the robot moves on a track or rail. The appendage from the base consists of an arm, either straight or jointed, to which the wrist and wrist flange are attached. The appendage is powered internally and moves an end-effector. Feedback devices sense the positions of the arm and joints and transmit the information to a controller.

The controller, which includes the computer and the implicit software, performs a threefold function: (1) it initiates the motions of the manipulator, sends the manipulator through a desired sequence of motions, and terminates the motions; (2) it stores position and sequence data in the computer memory; and (3) it interacts with the external environment. The software contains implicit operating and task programs. A task program is composed of a series of target positions through which the end-effector must pass to perform a given function.

The power supply provides energy to the manipulator's actuators. The actuators may be pneumatically, hydraulically, or electrically powered. Although pneumatically powered robots are lightweight, fast, and relatively inexpensive, most of the industrial robots in use today are hydraulically powered. Hydraulic robots have more physical strength and speed than either the pneumatically or electrically powered robots, with fewer moving parts and greater reliability. Electrically powered robots, which are increasing in popularity, are not as strong as hydraulically powered robots, but their movements are more precise and they require less space. Such advantages don't come cheap, however, as electrically powered robots are more expensive than those powered pneumatically or hydraulically.

he end-effector, usually built by the robot manufacturer, is a custom-made tool, gripper, and/or sensor mounted on a wrist flange at the end of the robot arm. In order to give the robot flexibility and adapt it to different tasks, the end-effector is interchangeable. Thus, the end-effector is treated as a piece of auxiliary equipment rather than an integral part of the robot. The end-effector may even require an independent power source.



Heath Company

HERO I By Heathkit

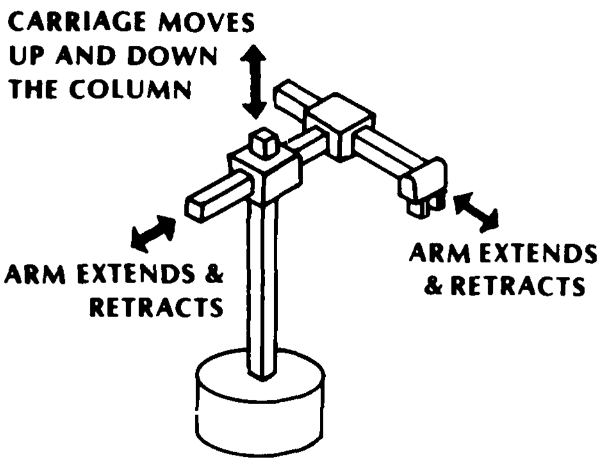
Introducing Robots into the Factory

At the outset, it is important to recognize today's manufacturing environment. Figure 1 presents a breakdown of typical manufacturing costs, by percentage. This breakdown is representative of the situation in defense, aerospace, electronics, and heavy industries in the United States. Materials account for the biggest "slice of the pie." Labor accounts for a smaller slice. The rate of direct to indirect labor fluctuates; however, a 50/50 split between direct and indirect labor often prevails.

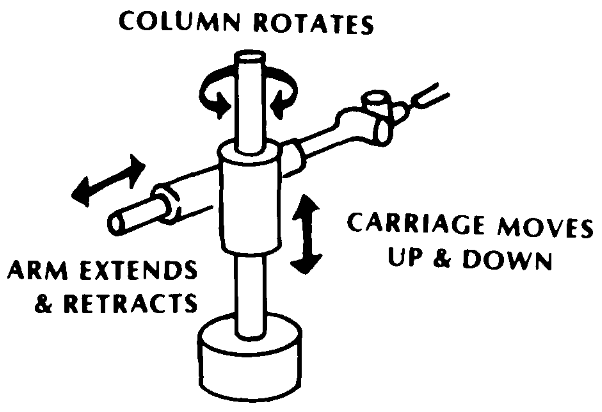
Let's examine the influence the introduction of robots into the factory can have on manufacturing costs. From the standpoint of industrial management, it is advisable to install equipment that will save 10 percent of a 10-percent cost entity rather than equipment that will save 10 percent of 1-percent cost entity. When we relate this to robots, it would appear that a one-for-one replacement of a worker for a robot would be desirable. However, it is also quite clear that there is a greater potential for cost-savings in supplementing indirect labor and reducing the cost of materials.

■ *Mr. Acker is a Professor of Engineering Management in the Research Directorate, Department of Research and Information, at DSMC.* ■

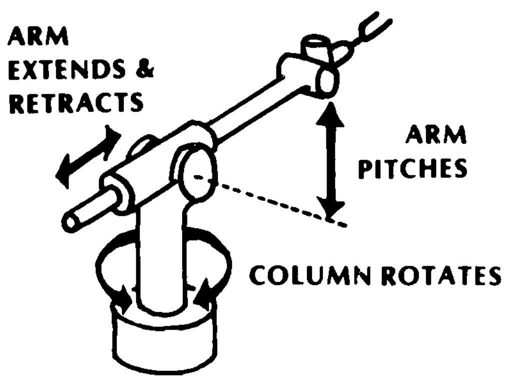
Basic Robot Design Configurations



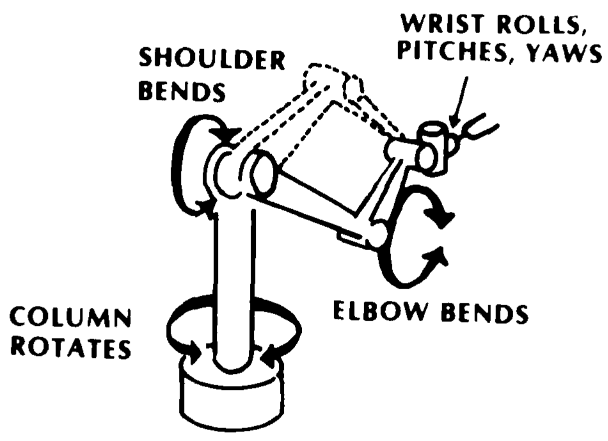
A cartesian coordinate robot consists of a horizontal arm mounted on a second horizontal arm which, in turn, is mounted on a verticle column. Both horizontal arms move in and out. The carriage for the second arm moves up and down on the vertical column which is mounted on a base. Thus, the working area of the robot, which is the easiest of the robot configurations to control, is rectilinear.



A cylindrical coordinate robot consists of a horizontal arm mounted on a vertical column which, in turn, is mounted on a rotating base. The horizontal arm moves in and out. The carriage for the arm moves up and down on the vertical column. These two members rotate as a unit on the base. Thus, the working area of the robot is a portion of a cylinder.

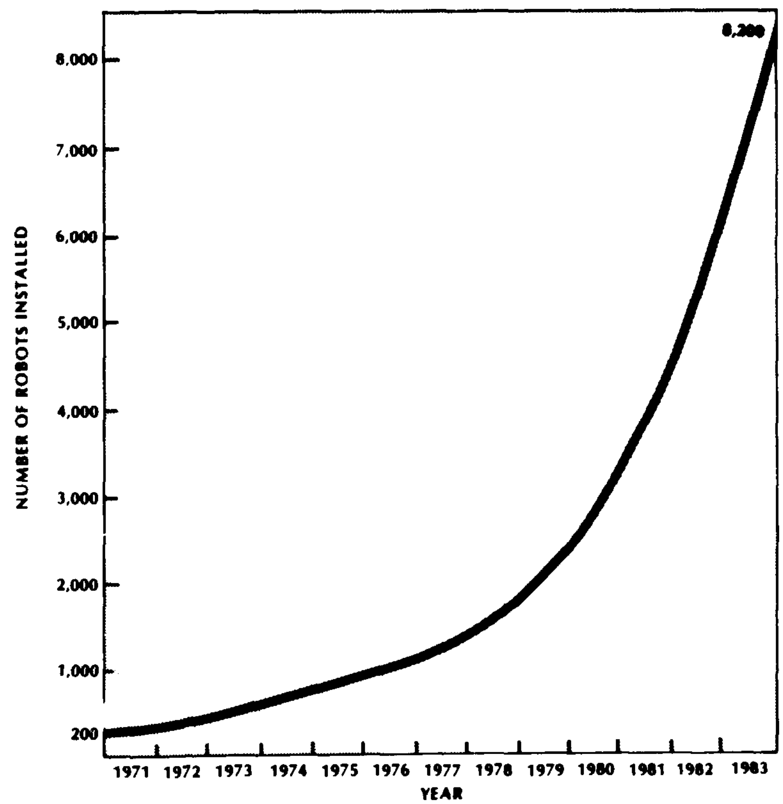


A spherical coordinate robot has a configuration similar to that shown above. The arm moves in and out, pivots in a vertical plane, and rotates in a horizontal plane about the base. The working area of the robot is a portion of a sphere.



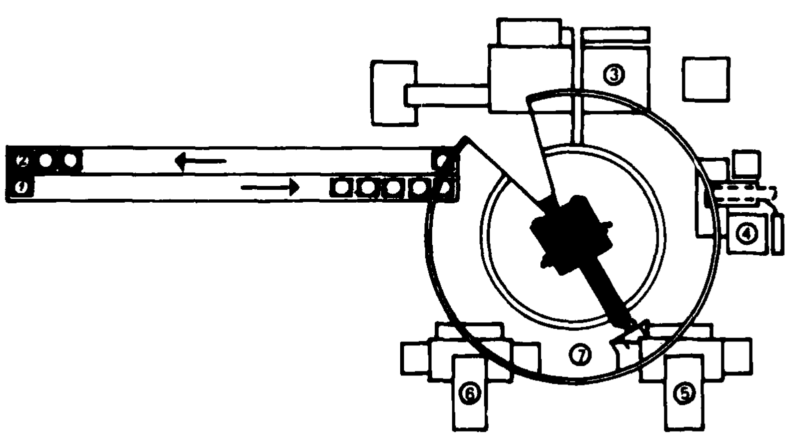
A jointed-arm coordinate robot consists of a trunk and a forearm, and an upper arm that moves in a vertical plane through the trunk. An elbow joint is located between the forearm and upper arm. A shoulder joint is located between the upper arm and the trunk. A rotary motion in a horizontal plane is provided at the shoulder joint. The working area of the robot approximates a portion of a sphere.

A robot represents a substantial investment; therefore, there are several factors a company should take into account before investing in one or more of them. First, there should be plenty of work for the robot. Payback will be faster if the robot works two, or even three shifts. Second, the robot should be considered as only one aspect of factory modernization, not as a substitute for it. Third, the robot should be put on a simple task first. This will permit the workers who program, operate, and maintain the robot to gain valuable experience before they have to handle complex robotic operations. Fourth, the first robot should be fully tooled. This will help the workers to avoid mistakes while they are learning to use it. Fifth, the workers who will program, operate, and maintain the robot should be given early, comprehensive training.

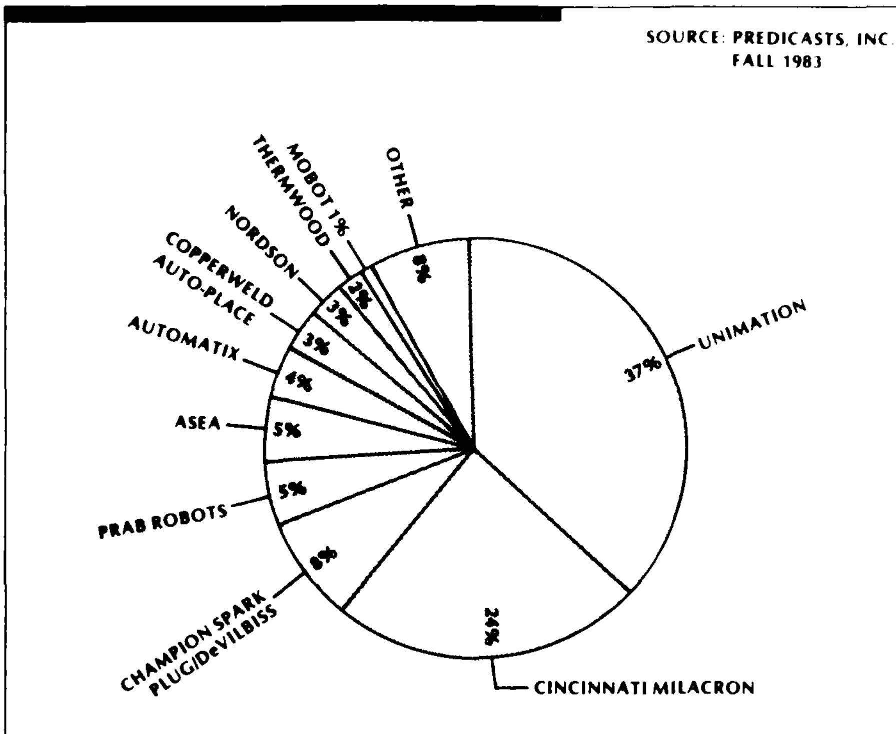


Industrial management generally recognizes that factories of the future need to be designed as systems. Unfortunately, about three-quarters of the new robots are being integrated into existing production lines. The robots are not being made a part of a new "system," i.e., a manufacturing center composed of cells, each having several work stations. Figure 2 represents a robot work cell in which machines group around a robot for efficient loading and unloading operations. The robot (7) picks up an unfinished part from the incoming conveyor (1) and transfers it successively to the four standard production machines—the numerically controlled lathe (3), a surface grinder (4), and two numerically controlled drill presses (5) and (6). Then it loads the finished part on the outgoing conveyor (2). Sometimes milling, deburring, and inspection also take place in such a robot work cell. Robots will gain wider acceptance if they become a part of such work cells in manufacturing centers instead of becoming just another piece of equipment in an existing production line. The centers provide significantly greater efficiency, flexibility, and effectiveness in manufacturing operations than do the production *lines* of older factories.

Figure 2. A Robot



n the factories of the future, the hard-technology view and the soft-technology view will form a global perspective of manufacturing systems. The hard-technology view will focus on the production of the product. This view will be represented by centers with cells containing robots and the other processing equipment as just discussed. The soft-technology view will focus on communications—the requirements for monitoring, controlling, and reporting the status of the systems. In other words, the technical and business systems will be integrated to become a part of the overall manufacturing system. If we understand this concept, then we can recognize why far-sighted industrial management is inclined to be more concerned with manufacturing centers than with individual robot applications.



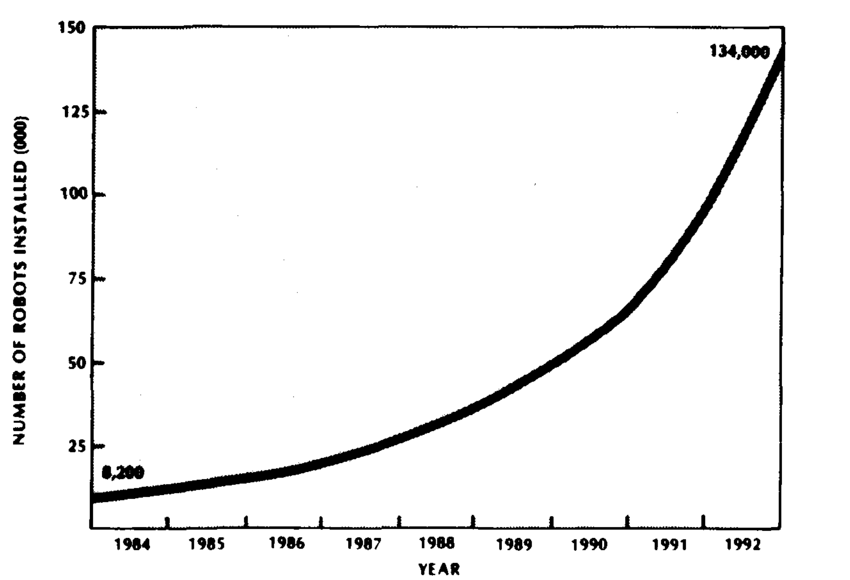
In 1970, almost a decade after the introduction of an industrial robot in one of the General Motors Corporation (GMC) automobile plants, there were about 200 installations in the United States. Although the growth of installations was slowed by recessionary conditions during the mid to late 1970s, the number of U.S. robot installations had increased to more than 8,000 by the end of 1983. (See Figure 3.)

The first major stage in the evolution of industrial robots—the period in which a definable robot industry emerged from the early development efforts—took place between 1970 and 1978. During that period, the basic technology was established. A number of U.S. companies started lines to manufacture robots. Also during that period, many large manufacturers—and a few small ones—set up initial robot installations. From 1979 through 1981, the number of U.S. robot manufacturers increased to meet the sharply increasing demands for robots. The market share of the robot business of U.S. manufacturers by 1982 is shown in Figure 4.[2]

In 1982, when the market had reached $190 million annually, the rate of growth of the robot industry slowed. The enthusiasm experienced earlier ended temporarily when many companies began to recognize the limitations of robots. Potential users postponed plans to purchase robots until needed improvements in the controllers and sensors could be made. One of the reasons for the slowdown in the rate of growth in 1982—as it had slowed in the latter part of the 1970s—was the general recession in the United States. However, it is encouraging to note that the annual growth in robot sales did continue.

Ultimately, the robot industry in the United States will achieve the high growth predictions made before the recent slowdown. (See Figure 5.) Most industry observers predict the annual unit sales of robots in the United States will increase from the estimated 2,000 per year in 1983 to nearly 38,000 per year in 1992. This would result in a U.S. robot installed base of about 134,000 by the end of 1992. If this prediction comes true, robots would then be used in 5 to 10 percent of the manufacturing applications for which they are suitable.

ow do the number of robot installations in the United States compare with the total number of installations in other parts of the world? A compilation of the world robot population at the end of 1982 is shown in Figure 6. Although the Japanese did not develop an industrial robot until 1969, the robot installations in Japan now represent slightly more than one-half of the total number of installations in the world. Western Europe has about 20 percent of the robot installations, and the United States about 18 percent.



Industrial Robot Applications

Over the years, the capabilities of robots have continued to increase. Much of the current robot technology was unknown just a decade ago—particularly control technology and programming. Now, robot manufacturers have discovered electronic logic and computer software. These technologies are making robots adaptable to an increasing variety of complex tasks.

Today, about 80 percent of the U.S. industrial robots are being applied to welding, material handling, and machine loading/unloading. The remainder of the robots are being used in the types of applications identified previously. About 40 percent of the robot applications are in the automobile industry. Another 40 percent are divided almost equally between foundries and the light manufacturing industry that is producing non-metal products. The remainder of the applications are in the heavy equipment, electrical/electronics, and aerospace industries.

Robots are justified within the production volume ranges shown in Figure 7. When fewer than 200 parts are to be manufactured per year, manual labor is usually less costly. Above 20,000 parts per year, hard automation is generally more cost effective.

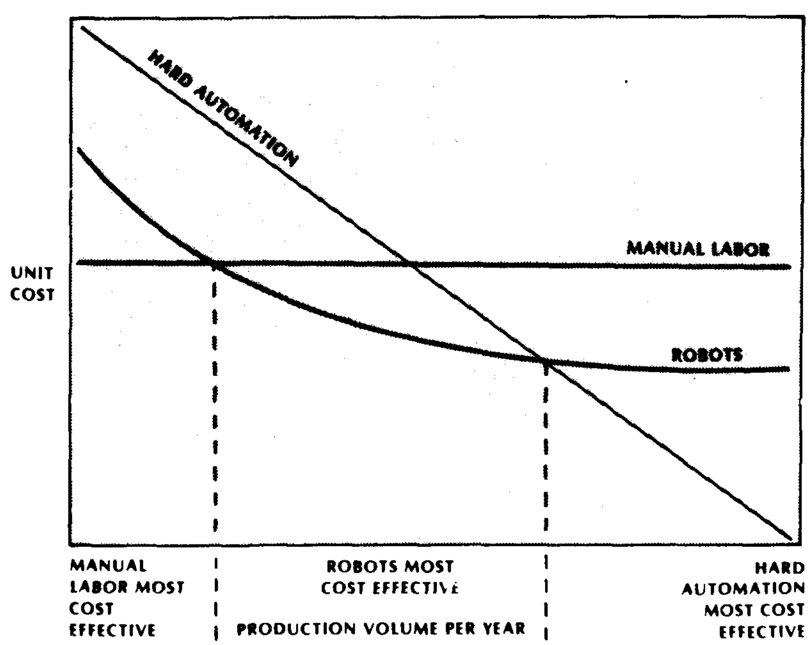
Robot manufacturers have generally held the line on the price of robot installations in recent years. Thus, we can expect many more manufacturing companies to give serious consideration to purchasing them. When they do, they may find themselves on their own. Although the number of applications will increase, each application will be unique in some respects. Because robot technology is still relatively new, there is little in-depth experience to call upon. As a consequence, the experience of most robot users is being guarded jealously, because they believe this experience gives them a competitive edge. It is quite possible, then, that the "wheel" is being reinvented many times over by industry in developing robots for new applications.

Now, let's examine the impact of robots on the work force.

	NUMBER	PERCENT
JAPAN	18,000	51
WESTERN EUROPE		
WEST GERMANY	2,800	8
SWEDEN	1,600	5
UNITED KINGDOM	800	2
FRANCE	700	2
ITALY	500	1
NORWAY	400	1
OTHER	400	1
TOTAL	7,200	20
UNITED STATES	6,200	18
UNION OF SOVIET SOCIALIST REPUBLICS	3,000	9
EASTERN EUROPE	600	2
TOTAL	35,000	100

The Robot vs. the Work Force

Although robots are used to save workers from hazardous, dirty, monotonous, and fatiguing jobs, the most significant and most common reason for employing robots is economic. Even when the justification for a robot is proposed under the guise of an altruistic motivation, or some factor other than pure economics, the underlying motivation for turning to robots is usually profit. It is essential, therefore, that consideration be given to all of the potential



costs and cost benefits of a robot installation. The quantification of the economics of factors other than direct labor replacement must also be considered as well as the savings related to labor replacement itself.

n 1981, the true cost of an hourly employee in the metalworking industries (except automobiles) was about $15/hour. In the automobile industry, it was about $20/hour. At the same time, the "all-included" cost of applying a medium-priced robot was about $6/hour. The hourly operating cost of a robot had only risen $2 since 1967. GMC Chairman Roger B. Smith said, "Every time the cost of labor goes up $1/hour, 1,000 more robots become economical."[3] GMC is now investing heavily in robots. It expects to spend about $1 billion to obtain 20,000 robots by 1990.

It is very difficult to predict the impact of robots on the work force. Robert Lubar has stated that every robot GMC employs replaces between 1.7 and 2.7 workers, depending on whether it is installed on the assembly line or assigned to a manufacturing task.[4] Considering industry as a whole, the displacement figure may be as high as six or less than one. If we assume three to be realistic, then about 20,000 industrial workers have been affected over the past 20 years. This does not mean that these workers entered the ranks of the unemployed. Jobs were created in marketing, developing, manufacturing, installing, operating, maintaining, and servicing the robots.

In 1983, William Bittle asked, "Where are the people displaced by robots going to find jobs? It isn't like 20 years ago when the United States was pre-eminent in the world economy."[5] The results of a recent Carnegie-Mellon University (CMU) survey answers this question, at least partially. More than 70 percent of the workers whose jobs were displaced were retained to supervise, operate, maintain, and service the robot, or to perform other jobs in the plant.[6] The results of the CMU survey indicated that robots increase the skill requirements for support jobs. One of the biggest challenges facing management when introducing robots into the work place is to determine the impact robots will have on the work force and what action the company should take on behalf of the workers.

The consensus among leaders in the manufacturing community is that the impact of robots on jobs in industry will not be great in the next decade, but it might become significant before the end of the 1990s. Timothy Hunt has commented, "We do not think the introduction of industrial robots will be a catastrophe. You will not wake up tomorrow and find your job gone."[7] In the 1980s robots will keep

jobs in the United States that could have been shipped abroad. According to Data Resources, Inc. (DRI), there will be a net gain in the manufacturing work force during this decade. By 1990, there will be a net gain of 16 million jobs, including 2.5 million in manufacturing. Most of the new jobs will be in the service industries.[8]

tudies of the affect of robots upon society have begun. The CMU study indicated that the total robot-caused job losses to date is a small fraction—about two-tenths of 1 percent of the 10.4 million craft workers, semiskilled operators, and laborers in relevant industries. The CMU report indicated that by 1990 robots will replace only 2 percent of the work force—perhaps less. Even this estimate is higher than the estimates generally used by the business community. Business executives tend to believe that only the largest corporations will purchase or develop robots. This is unfortunate, because the CMU report states that using robots in factories completely redesigned to take advantage of their capabilities could cut unit costs as much as 25 to 30 percent.

Arthur Hughes has sugge ted that "thinking of robots as man (work force) amplifiers, and not as man (work force) supplanters, may go a long way toward allying our fears about the future."[9]

Gaining Union Acceptance

Union acceptance of robots in the factory is being substituted for confrontation. The auto workers, machinists, and electrical workers unions have been the most receptive. According to a recent report, management at the Ford Motor Company is giving members of the work force a voice in their work environment and in the manufacturing processes used. Instead of taking an adversarial role, union leaders are ensuring that their members receive training and develop expertise in robot operations. The membership of the United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW) has been taking the viewpoint that robots are just one of the technological advancements facing the union today. According to Thomas Weekley, the UAW membership generally favors the introduction of robots, and has recognized robots as an essential means of promoting economic progress through increased productivity.[10] Increased productivity means additional benefits to management, but workers' wages, working hours, fringe benefits, and safety improve as productivity increases. Productivity, therefore, is recognized and accepted as a necessity for advancement of personal and company goals.

The demands for quality, low-cost goods make increased productivity essential for economic progress. In the 1970s, the UAW included the following clause in major contracts:

> The improvement factor provided herein recognizes the principle that a continuing improvement in the standard of living of employees depends upon technological progress, better tools, methods, processes and equipment, and a cooperative attitude on the part of all parties in such progress. It further recognizes the principle that to produce more with the same amount of human effort is a sound economic and social objective.

hen a company chooses a simple application for its first robot, the work force may respond to its installation with enthusiasm. After all, a robot can offer a worker relief from dull, dirty, or dangerous work. Robots don't always receive acceptance so readily, however. Robots displace workers and, over the long term, robots will reduce the need for non-skilled labor. In companies like General Motors, IBM, General Electric, and Westinghouse, where integration of robots has been successful, management has solicited ideas from workers about how to use robots to improve manufacturing operations without causing havoc for the work force.

The unions, of course, want to protect the work force (source of its members) from possible displacement. Therefore, some union contracts now restrict technological change. These restrictions may take one of the following forms:

- 10 percent of the companies must retrain a displaced worker who qualifies for a new job.

Servo versus Non-Servo Robots

An industrial robot may be classified as either servo or non-servo controlled. The common characteristics of each type are presented below.

Servo Robot

Typically, robot is hydraulically or electrically powered and can be programmed to stop at multiple points along a path. It normally contains from 5 to 6 degrees of freedom.

Robot executes smooth motions at controlled speeds with a positioning accuracy between ±.020 inches and ±.050 inches. In some models, acceleration and deceleration are controlled.

Robot has a positioning repeatability between ±.030 inches and ±.050 inches.

Robot is flexible. The axes of the manipulator can be programmed to any position within their travel limits.

Controller usually permits storage and execution of more than one program. Reprogramming is accomplished by altering the software in the (controlling) computer.

Compared to a non-servo robot, this robot is more difficult to maintain, and tends to be slightly less reliable than a comparable non-servo robot. Uptime is 95–96 percent.

Cost of robot ranges from $30,000 to $135,000.

Non-Servo Robot

Typically, robot is pneumatically or electrically powered and can stop at multiple points along a path. It normally contains from 2 to 5 degrees of freedom.

Robot is capable of high speed motion with a positioning accuracy of ±.010 inches.

Robot has a positioning repeatability of ±.010.

Flexibility in terms of program capacity is limited.

Operation, programming, and maintenance are simple. Reprogramming is accomplished by adjusting the physical mechanisms.

Performance is reliable. Uptime is about 97 percent.

Cost of robot ranges from $5,000 to $40,000.

13 percent of the companies must make a concerted effort to retrain a displaced worker

18 percent of the companies must retrain a displaced worker

These provisions reduce worker fear, but at the expense of management flexibility. It seems unlikely, then, that such provisions will gain a wide acceptance in the years ahead.

It appears that growth in the application of robots will continue while many U.S. companies adopt a "familial" approach toward members of the work force. This approach has been working well in Japan. When this approach is taken by industry, union membership becomes less attractive. In those U.S. industrial firms where union membership is strong, union leaders have been prone to advocate this approach, because it will help to ensure jobs are not shipped outside the United States.

Because the transition to greater use of robots in manufacturing operations will take place over a period of many years, the number of jobs that may be lost by the work force will tend to flatten out on a yearly basis. If company management and union leaders recognize the need to train members of the work force for new responsibilities in the highly automated factories of the future, job loss will be kept minimal, and U.S. industry will be able to compete effectively with its foreign rivals in the world market.

Gaining Management Acceptance

In the design or redesign of every manufacturing system, management has the opportunity to explore the options concerning the relationships among people, technology, and cost. Managers, normally concerned with technological improvements and reduction in costs, can ill afford to neglect the changes that will be wrought on the social system in the work place by robots. Innovative ways to integrate disparate goals must be found.

ne of the obstacles to using robots efficiently in the factory, according to Alan Letzt, is the "anthropomorphizing of the manufacturing process." In most factories, the manufacturing processes have been designed to facilitate operation by the work force. However, "human capabilities, orientations, and methods may not be the most effective way of performing an assembly task. . . ." Company management, supported by manufacturing engineering, must review the manufacturing methods used, and encourage development of robots or hard automation to take advantage of the most efficient methods available.[12]

If U.S. industrial management continues to emphasize productivity improvement, higher quality products, and increased competitiveness in the world market, robots will have to be used in greater numbers. Of course, this will not come about without some special effort, because management will have to deal with displacements in the work force at the same time it is adapting to new technology. Therefore, it is imperative that management scrutinize the social system within its manufacturing operations with the same blunt objectivity that it applies to the technological and economic systems. Hewlett-Packard, Westinghouse, and IBM, to name a few, have done this successfully, and they have taken the lead in industry by establishing "no-layoff" policies.

Gaining Public Acceptance

To gain large-scale public acceptance of industrial robots, both robot manufacturers and users will have to project a clear picture of what robots are and how they can be applied effectively. Robert Skole and others recognized this need almost 10 years ago.[13] At that time he prepared an informational check list to "spread the word and bring about public acceptance." The list contained many suggestions for actions that could be taken to ensure the public understands and appreciates the benefits to be derived from robot installations. Included in that list were the following suggestions for management.

1. Involve the work force in the introduction of robot installations.
2. Make the benefits resulting from robot installations clear to the work force.
3. In concert with the work force and union leaders, consider new assignments for workers as soon as a robot installation is planned.
4. Undertake an "outside" public relations program after the workers are aware and fully convinced of the advantages of a robot installation.
5. Don't hold press showings until workers, union leaders, safety officers, and others who may be directly involved have been fully informed of plans for a robot installation.
6. Ensure that press releases—the written word—give the full story of a new robot installation. Don't neglect the human aspect in press releases, i.e., include statements by workers and union leaders indicating that they recognize the importance of the new robot installation.
7. Ensure that public relations statements make it very clear that workers will be needed to supervise, operate, maintain, and service robot installations.
8. Encourage everyone involved in robot development, manufacture, and application to spread helpful information about a new robot installation.

ccording to Skole, "The initiative and effort devoted to informing the public about robots will help gain general understanding, acceptance, and realistic enthusiasm."[14] A company that takes this approach may avoid some of the criticism it could receive, especially criticism by the work force based on what might be a sincere fear of the unknown.

What's Ahead in Industrial Robotics

In 1984 we can build good numerically controlled machines. During the past 10 to 15 years, the cost of computers has decreased to the point where we can dedicate a single computer to a robot. Soon it will be practical to use many computers to control a single robot. Microcomputer technology will not only make it possible, but it will make the production of such robots both simple and inexpensive. The computers needed for robot control systems already cost only a fraction of the cost of mechanical hardware.

James Albus lists six technical problems associated with robotics that have to be solved.

1. *Structures*: The structures of future robots will have to be made

sufficiently stiff and rigid to meet the fundamental requirements of accuracy and repeatability.

2. *Sensing*: Robots in the automated factory of the future will have to be able to see, feel, hear, and measure the position of objects in many different ways. Therefore, the data from sensors will have to be processed and information extracted that can be used to successfully direct robot actions.

3. *Control*: Robots with sensors will have to be able to accept feedback data at a variety of levels of abstraction and have control loops with a variety of loop delays and predictive intervals.

4. *World Model*: Robots will have to store and recall knowledge of the world about them that will enable them to behave intelligently and show some insight regarding the spatial and temporal relationships inherent in the work place.

5. *Programming Methods*: The techniques for developing robot software will have to be improved.

6. *System Integrating*: Robots will have to be integrated into the overall factory control system.[15]

Fortunately, the technical problems are amenable to solution; however, until the problems are solved, robot capabilities will be limited, and robot applications will continue to be relatively simple.

The discussion of problems should not be looked upon as placing a "wet blanket" on future prospects. The future for industrial robots is bright. In the next decade, robots will be become more readily available and applied more extensively. During this period, the robot industry will probably become segmented into three major categories.

Total factory-automation companies that will use robots as interface devices, rather than as stand-alone devices.

Specialty companies that will concentrate on particular robot applications, such as spray painting or machine loading. These companies will become proficient in their chosen specialties and eventually dominate their fields.

Turnkey system suppliers that will be concerned with many robot applictions, including planning, robot selection, site preparation, robot installation, education training, and follow-on assistance.

oday, robots can handle parts that are similar in size and orientation, and placed in the same general location. And a few advanced state-of-the-art robots can "look" for a part. However, future robots will be able to find specific parts with "TV" eyes, and orient the parts as required. Also, sophisticated sensors will be able to "feel" the difference between various part sizes and/or part orientations. A memory, linked to the eyes, will be able to tell the arm which part to select. Further, robot memories will help in sorting out and removing wrong or broken parts. The major problem that has to be overcome before these advances are possible is to reduce the cost of vision sensors. Presently, the sensor costs start at about $120,000. This is usually too high a price to pay, if one takes into consideration the length of the payback period.

Robot manufacturers have been reluctant to talk about "smart" robots—those capable of decision-making—because, for the most part, industry has only started to utilize the capabilities of existing robots. If industry's interest in robots grows as expected, smart robots will be used in many U.S. factories in the 1990s. The smart robots will be able to understand spoken commands, or they will be able to convert printed language into operating commands. Also, the elementary intelligence available in some robot programs will be able to give the robot the ability to change a program on its own, or to modify a program to cope with a new situation. Fortunately, the more sophisticated robot designs will not make the earlier designs obsolete. The new robot designs will be capable of performing more demanding tasks, and the older robots will continue to perform their previously assigned tasks.

The robots of the late 1980s and early 1990s will be more economical, reliable, and versatile (as well as programmable) than those in use today. They will continue to provide a solution to the problems that are encountered when manufacturing takes place in hazardous, unpleasant, or monotonous environments. Robot qualities and benefits will exert a positive influence on the robot market, a market that may reach $3 billion to $4 billion in sales by the mid-1990s, with the heaviest demands coming from the electronics, automobile, and aerospace defense industries. Because of the benefits available through the application of robotics within specific ranges, industrial managers will find ways to accommodate them in the factories. Products will be designed for robot handling. Massive shifts in the nature of factory skills will be made with little, if any, loss in the work force. These events, of course, will increase the size of the market for educational robots—robots that tend to mimic their industrial counterparts. Educational robots will be used in teaching subjects other than robotics. They will be the segments of factory automation or electronics courses.[16]

Other advances in robots on the horizon are those with the following characteristics:

—Higher speeds, better stability, and improved controls;
—Multiple-armed configurations; and
—Off-line programming in a high-order language.

he potential advances show great promise; however, the greatest advance in robot use may come about as a result of more effective manufacturing management techniques. For example, "group technology" will be a boon to robots. This technique involves classifying parts to be manufactured into families. Parts are never placed in bins for storage or transferred to other areas. The parts maintain their orientation throughout the entire manufacturing process. In addition to group technology applications, robots will be used in computer-aided manufacturing, product assurance systems, and automatic warehousing.

Final Observations

In most U.S. companies that successfully introduced robots into their manufacturing operations, management ensured that the move was made gradually; steps were taken to gain line management support at the outset; workers were informed about the benefits of using robots; a concerted effort was made to retain and retrain displaced workers; and the

union (if any) was informed of the plans and the progress. Of course, there have been some problems in companies where robots have been installed, but, for the most part, the problems have been minimal and disposed of easily because management has taken the approach just outlined.

There will be more and smarter robots in the factories of the future, and the conflict between the work force and management will continue to some degree, especially if the introduction of the robots appears to be threatening to the work force. It is inevitable that jobs will be lost to robots; however, normal attrition and a continuing shift from goods-producing jobs to service-producing jobs will offset the possibility of high unemployment. Today, if we exclude the farm workers, about one-quarter of the remaining U.S. workers are in goods-producing jobs, and the other three-quarters are in service-producing jobs. It should also be kept in mind that the robotics industry itself will provide new employment opportunities. And, of course, there will be a need for robot operators, engineers, programmers, and technicians. Also, there will be a need for robot maintenance personnel who have both electrical and mechanical skills.

Forward-looking industrial managers recognize that the introduction of robots will bring about major changes in manufacturing operations. These managers are looking beyond the simple one-for-one replacement of workers and toward understanding the interactions within the manufacturing operations so they can identify those applications where robots can be applied successfully. Further, these forward-looking managers are calling for a systems approach to conceive, define, and build robotic cells. Such an approach will ensure that three goals for successful manufacturing operations will be met—efficiency, flexibility, and effectiveness.

In the final analysis, it must be recognized that robots will continue to present industrial management with a tremendous challenge. The industrial firms in which management meets the challenge successfully will prosper; the firms in which management fails to meet the challenge head-on may fall by the wayside. In the long term, the fundamental alterations in industry and business caused by the application of robots may profoundly affect the course of human civilization.

In the fourth century B.C., Aristotle wrote, "If every instrument could accomplish its own work, obeying or anticipating the will of others . . . if the shuttle could weave and the pick touch the lyre without a hand to guide them, chief workmen would not need servants nor masters slaves." Today, his vision is becoming a reality in factories throughout the world. ■

Notes

1. Frederick W. Rosen, "There's a Functionoid in Your Future," *American Way*, February 1984, pp. 147-149.
2. *Factory of the Future*, a market research report (Number E82) issued by Predicasts, Inc., Cleveland, Ohio, 1983.
3. John Holusha, "GM Shift: Outside Suppliers," *New York Times*, October 14, 1983, p. D-1.
4. Robert Lubar, "Why Unemployment Will Hang High," *Fortune*, June 14, 1982, p. 116.
5. William Bittle, Economist, Headquarters, International Association of Machinists, 1983.
6. Professor Robert U. Ayres and his research associate, Steven M. Miller, of Carnegie-Mellon University. *Robotics Applications and Social Implication* (Cambridge, Mass. Ballinger Publishing Co. 1983)
7. Timothy Hunt. *Robotics Human Resource Implications for Michigan*. W. E. Upjohn Institute for Employment Research study, 1983.
8. "High-Tech Blessing or Curse?" *U.S. News and World Report*, Volume 96, Issue 2, January 16, 1984, pp. 43-44. Data Resources, Inc., also known as DRI, is a consulting firm in Lexington, Mass.
9. Professor Arthur J. Hughes of St. Francis College, "Robotics Effect on Japanese and American Labor and a Practical Application in the New York City Department of Sanitation," *Public Productivity Review*, June 1983, p. 116.
10. Thomas L. Weekley, UAW Member, *A View of the United Automobile Aerospace and Agricultural Implement Workers of America (UAW) Stand on Industrial Robots*, Proceedings of the Robot IV Conference, October 1979.
11. *Basic Patterns in Management and Union Rights*, 1983 Daily Labor Report, No. 29, D-1, Bureau of National Affairs, February 10, 1983.
12. Alan M. Letzt, Program Vice President, SMC Management Technology, "Robotics: A Key to the Productivity Puzzle," *Chemical Times and Trends*, July 1982, p. 23.
13. Robert Skole, McGraw Hill World News (Sweden), *An Industrial Robot Public Relations Checklist*, Fifth International Symposium on Industrial Robots, September 1975.
14. *Ibid.*
15. James S. Albus, *Robotics*, an unpublished paper prepared at The National Bureau of Standards, 1983.
16. Rita R. Schreiber, "The ABCs of Education Robots," *Robotics Today*, February 1984, pp. 54-57.

Getting Serious About Industrial Base Planning

The Department of Defense and industry must work together better than they have in the past if the country is to have the defense industrial capability it needs.

Lieutenant Colonel O. M. (Mike) Collins, USAF

he primary objective of present U.S. national security and Department of Defense (DOD) policies is the deterrence of military conflict along the entire spectrum of war. Should deterrence fail, the nation should then be appropriately positioned to bring all of its national resources to bear to positively determine the outcome. Successful accomplishment of these objectives is clearly dependent on the implementation of selected technology investment strategies and production of the necessary military hardware to build required force structures and war-fighting capabilities. Sustaining such deterrent and war-fighting capabilities over the long term is inevitably linked to the effectiveness and efficiency of the U.S. industrial base.

Recent defense policies concerning the efficiency and effectiveness of the weapons acquisition process have centered on former Deputy Secretary of Defense Frank C. Carlucci's cost reduction initiatives under the Defense Acquisition Improvement Program (DAIP). In addition, the Deputy Secretary issued further policy guidance in March 1982 expanding the Industrial Preparedness Planning (IPP) Program to include peacetime acquisition efficiency and effectiveness as an IPP objective. He thus linked industrial base and preparedness planning policies with DAIP. Other objectives in the new IPP program concern the more traditional requirements to maintain a surge production capability for critical military items and to provide the foundation for possibly transitioning to an industrial mobilization posture in the event of a protracted conventional war.

Accordingly, the DOD concept of industrial responsiveness, as postulated by the 1980 Defense Science Board Study, combines the two objectives of increasing the efficiency of the peacetime acquisition process through reduced program unit costs and lead times, and making it possible for industry to accelerate production rates to meet surges in demand (under both peacetime and wartime conditions). The primary shortcoming with these current DOD industrial base policies is that they do not specifically address the establishment of a long-range planning function that systematically links manufacturing resource, technology development, and force planning objectives to yield the greatest marginal benefits in terms of total military capability (including both deterrent and war-fighting factors).

nother glaring deficiency is the lack of formal, long-range cooperative planning between industry and DOD acquisition communities to ensure the continued availability of critical strategic resources. Current IPP procedures focus primarily on the short-term production surge and industrial mobilization capabilities for specific military end-items using the DD Form 1519, "DOD Industrial Preparedness Program Production Planning Schedule." Without an effective long-range planning process to provide visibility into policy and programmatic options concerning the peacetime industrial base, the chances for a true synergistic relationship between DOD and industry in meeting long-term cost reduction and preparedness objectives will continue to be significantly constrained.

Policy-Related Problems

The predominant problem in implementing the new industrial base, preparedness, and DAIP policies is the continuing lack of stability in the DOD acquisition process. Like a conditional probability, stability in the budget process is a clear prerequisite for the actual implementation of industrial productivity and other measures directed at reducing acquisition costs. Short-term reductions in real program costs through the introduction of new manufacturing equipment, methods, and processes are dependent on long-term improvements to the industrial base.[1] Any short-term program cost savings not based on well-planned, longer-term improvements to the efficiency of the industrial base are random and difficult to predict.[2] And these long-term improvements are dependent on the ability of DOD executives to significantly reduce business uncertainty in the acquisition process and provide credible incentives for corporate decision-makers to direct productivity-enhancing capital allocations into defense-related production lines.

Another constraint affecting the relationship between the new cost reduction and preparedness policies is that DOD policy also requires U.S. defense industry to be domestically self-sufficient in the production of military items identified as being critical for wartime use.[3] Under wartime scenarios where the length of the presumed conflict exceeds 2 or 3 months, combat sustainability for U.S. tactical and mobility air forces is

■ *Lieutenant Colonel Collins is Deputy Commander of the Air Force Plant Representative Office at Pratt and Whitney Aircraft in West Palm Beach, Fla.* ■

directly linked to the production acceleration capabilities of key defense prime contractors and their vendors. And if some amount of production capacity is retained as a buffer for production surge and mobilization, this added capacity then becomes an additional constraint against achieving the objective of minimum unit production costs for the peacetime acquisition program. The amount of such buffer capacity required is related to the wartime scenario thought to be most likely to occur and for which the services are required to use as a wartime materiel planning baseline. Further, since wartime planning scenarios are somewhat dynamic over time, an additional element of instability is built into existing industrial preparedness planning mechanisms.

From the peacetime acquisition efficiency perspective, continued instability (budgetary, requirements, and technical) in the DOD acquisition process is the basic reason for the continued lengthening of acquisition lead times and increasing real program cost growth of five percent per year for aerospace weapon systems.[4] This institutional instability will continue the cause-and-effect relationships that discourage both productivity-enhancing capital investments in defense production lines and the entry of new firms into the defense subcontractor/supplier base. And without sustained manufacturing productivity growth and the addition of new firms competing for DOD's business (especially at the subcontractor/vendor levels), we can expect continued upward pressure on future real weapons costs.

Given some degree of improved stability over the long term, the key to meeting defense industrial resource management challenge is planning.[5] Unless joint DOD and industry resource base planning is effectively accomplished in advance of the annual Program Objective Memorandum (POM), implementation of the various cost efficiency and preparedness initiatives becomes budget-limited. In the case of multiyear procurement, inadequate planning in advance of the annual POM submission limits the potential program savings due to shortfalls in funding to cover possible cancellation charges for recurring costs. This same problem afflicts the implementation of all the other productivity and preparedness initiatives. The procedural problem is that weapon system program managers have not been effectively integrated into a formal planning process that identifies and analyzes alternative productivity and preparedness business strategies in advance of the POM submission.

The overriding problem with the new capital investment incentive initiatives is that they are focusing on the wrong basic objective and are based on some assumptions that may not be valid.

Current DOD industrial base policy initiatives had their geneses in numerous DOD studies between 1975 and 1981. These studies focused on symptoms that foretold an erosion of the defense industrial base. These symptoms included long peacetime material lead times, low levels of real profits (return-on-sales) for defense contractors, a nonexistent production surge capability, increasing unit production costs for military hardware, declining U.S. industrial productivity growth, and loss of the U.S. international competitive advantage in high technology markets. The trends identifying these symptoms are clearly cited in numerous places, foremost being the DOD Profit '76 Study, the 1976 and 1980 Defense Science Board Studies of Industrial Readiness and Industrial Responsiveness, respectively, and the December 1980 congressional hearings on the "Ailing Defense Industrial Base" before the House Armed Services Committee.

The trends that have received the most publicity relative to the cost efficiency of the DOD acquisition process are those concerning depressed U.S. industrial productivity growth and low rates of capital expenditures to sales, especially within the U.S aerospace industry.[6] As a result, policy solutions to incentivize corporate capital investments have been promulgated in two specific areas: (1) changes to contractual policies relative to negotiated profit objectives and progress payment rates to increase the cash flow of defense contractors; and (2) the provision of government "seed money" as direct performance incentive payments to specific contractors to bring high technology industrial modernization to the factory floor. The second approach is known as the Technology Modernization (Tech Mod) Program, and generally utilizes discounted cash flow procedures to determine the financial incentive that should be paid to the defense contractor for making stipulated cost-reducing capital investments. While these approaches are obviously valid, their implementation is being constrained by numerous interdependent factors.

The overriding problem with the new capital investment incentive initiatives is that they are focusing on the wrong basic objective and are based on some assumptions that may not be valid. The primary objective of DOD's new Industrial Modernization Incentives Program (IMIP) is to maximize industrial productivity growth.[7] But the policy objective should be to reduce unit production costs (given the required level of product quality to ensure operational effectiveness) and/or to improve production surge capabilites for critical pieces of military hardware. Under this slightly modified philosophical approach, an appropriate capital investment incentive could more easily be tailored as one option in the implementation of a comprehensive effort to improve overall industrial responsiveness. In other words, the implementation of a capital investment incentive should be a means to an end and not an end in itself.[8] Furthermore, any such decision involving the use of appropriated funds to increase the efficiency of a specific contractor's production

capability should be analyzed and justified based not only on the cost reduction potential, but also on the effort's contribution toward meeting industrial preparedness objectives.

To ensure proper accountability, faith alone may not be adequate for those public officials who are bound to be second-guessed. A high probability of success should exist concerning expected cost efficiency benefits before any government-funded capital investment incentive is contractually implemented—unless offset by overriding industrial preparedness or mobilization benefits. The problem again is the nonexistence of any planning mechanisms that permit benefits measurement and tracking, including the measurement of manufacturing productivity changes at the weapons program and industrial plant levels.

Without a clear audit trail for cost reduction benefits, the only available statutory and policy basis for enhancing one contractor's production capability over another's is linked to the industrial and emergency preparedness sections of the Defense Production Act of 1947 and Presidential Executive Order 11490. Otherwise, with the NATO participating countries operating under a waiver to the Buy American Act,[9] greater cost reduction potential could possibly be achieved by opening up more weapons programs and military hardware items to the market forces of international competition.

Industrial Base Planning Challenge

A decision to establish a credible industrial planning process must come from the highest levels within each military department and be supported throughout the acquisition management hierarchy. However, in making such a decision, certain management philosophies must be firmly understood. For example, will the desired industrial planning process support a proactive or reactive acquisition management philosophy?[10] If the decision is to pursue purely reactive goals, then the current DD Form 1519 planning process is probably adequate. This planning procedure focuses on the collection of information defined by past production history and in terms of a point-solution wartime scenario.

f the decision is to establish a proactive acquisition management philosophy, managers at all levels must be involved to plan and shape future industrial base resources to match future force and technology objectives. Thus, the present "hidden agenda" objective of maintaining maximum short-term budgetary flexibility should be subrogated to the long-term objective of incentivizing the creation of a defense production capability primarily characterized by maximum economic efficiency and constrained only by those objectives concerning the maintenance of excess capacity for production surge and mobilization reasons.

So, given a decision to pursue a proactive acquisition management philosophy regarding the defense industrial base, what can DOD acquisition executives do over the long term to cause aerospace corporate executives to create a more efficient and effective market structure at both the prime contractor and sub-tier levels?

First, a credible industrial planning process should be established to guide the development of production base resources in transitioning from the present to the future. The basic policy objective for the shorter-term should be the enhancement of DOD's ability to translate national industrial resources into increased military capability by delivering the funded Five-Year Defense Program and be prepared to surge production to support potential military and political crises. Instead of basing the maintenance of a production surge capability on a point-solution surge scenario, the degree of surge capability should be based on a conscious management decision to be prepared to surge the peacetime production rate of a given weapon system or piece of equipment by some factor within a stipulated time period. For example, such a decision might be to include the necessary fiscal resources in the FY 86 POM to be prepared to surge the peacetime production rate of the F-16 aircraft on October 1, 1986, by a factor of two between October 1, 1987, and September 30, 1988.

For the longer term, the industrial planning process should ensure the availability of industrial base resources to satisfy stipulated military force and technology objectives. For Air Force Systems Command, a planning process called "Vanguard" currently exists to provide integrated program planning, investment, and force structure acquisition strategies as a tool to guide the budgetary and technology planning processes.

An implicit assumption currently in all force and technology planning processes is that the necessary industrial resources, i.e., strategic and critical materials and a reliable vendor resource base, will always be available to produce the required military forces and weapons technologies. This assumption is particularly erroneous in today's economic and political environment, which encourages businessmen to take maximum advantage of their ability to rapidly shift capital around the world as well as among industrial sectors; thus, the potential for sectorial deindustrialization resulting from increased worldwide capital mobility.[11] Without an institutional process for achieving some degree of congruence between corporate decision-makers and DOD decision-makers, the Defense Department may be forced to accept the reality of having to rely substantially on an international, or foreign, industrial base with all its corresponding political uncertainties. The policy and statutory basis for such a planning system is linked to the DOD Industrial Base and Preparedness Program, which has been greatly revamped over the past year and a half.

A Proposed Industrial Base Planning System for the Aerospace Sector

Under the old IPP program, the services conducted piece-part planning relative to the aerospace sector. Except for the setting aside of industrial equipment in Plant Equipment Packages, none of the recommendations from the past IPP were ever implemented relative to the aerospace sector. While there are many reasons why the old IPP Program did not work relative to this industrial sector, the basic problem was that the planning was not perceived as being important by the program management community. Since the

old planning looked only at wartime support, it did not receive high priority with program and logistics managers who were primarily concerned with cost and schedule parameters relating to peacetime production and support. In addition, there was no conceptual integration between the program and logistics managers and their industrial counterparts in terms of implementing the war plans.

he primary difference in the new planning program introduced by Deputy Secretary Carlucci's memorandum of March 6, 1982, which was described earlier, is the conceptual expansion of IPP objectives to include the efficient and effective acquisition of the peacetime Five-Year Defense Program. The impact of this new industrial planning guidance can be significant. To be effective, program and logistics managers should be tasked in advance of the annual POM submission to prepare an Industrial Base and Preparedness (IBP) Plan. The purpose of the IBP Plan should be to integrate the industrial base policy objectives into their acquisition planning activities. The purpose of each IBP Plan would be to identify the optimum program structure for efficient peacetime production and effective surge/mobilization support during the planned funding period.

The program manager's planning should utilize a total system perspective at the industrial plant level by integrating all appropriate industrial resource allocation decisions concerning labor, materials, and machines. The result of the planning should be the identification of those targets of opportunity in the IBP Plan for achieving maximum peacetime program cost efficiency, subject to the constraint of ensuring an adequate surge production capability for selected weapon systems. Where a specific program manager is forced to compete with other DOD programs at a specific contractor's plant, the IBP Plan should be coordinated by all applicable DOD agencies. Where more than one DOD agency is relying on production resources at a given production plant, it may be more appropriate to create a jointly funded industrial base contract, fashioned after the traditional facilities contract, to integrate the annual planning and implementation of all industrial productivity and preparedness improvements.[12]

Under the new industrial planning policy as defined in the FY 84-88 and FY 85-89 defense guidance documents, the key document is the preparation by each service of an annual Production Base Analysis (PBA). The publication of each service's PBA is intended to be the end result of the annual industrial planning process. Each service's PBA should provide its military and civilian leadership and the Office of the Secretary of Defense with the necessary information to identify which industrial bottlenecks and areas of inefficiency should have fiscal resources allocated to them during a future funding period for the greatest marginal enhancement in total military capability.

The success of the industrial planning function will depend on the ability of the acquisition process to integrate the planning functions and the acquisition/contracting functions.

nformation should be analyzed from available economic and financial data bases relative to the overall defense industrial base, e.g., the Defense Economic Impact Modeling System, and key defense contractors, and their industrial sectors, e.g., Dun and Bradstreet or Standard and Poor's. Such data should be integrated with data from in-house sources and contractual industrial planning assessments with key defense contractors, as well as program manager IBP Plans, to identify specific cost and lead time reduction opportunities at the industrial plant and weapons program levels. The planning documentation should also identify those measures that should be implemented to support defined surge and mobilization production requirements. The output of each annual planning exercise should result in the identification of specific projects and acquisition strategies that should be advocated during the POM preparation process. Following are some examples of the types of projects and business strategies that could be incorporated into the POM for the planned funding period

Materials Management

1. Identification of materials and components where economically ordered quantities could be optimized through the use of multiyear prime contracts and/or multiyear subcontracts. The prime contractor's make-or-buy plan should be used as the decision document in determining the most effective allocation of work to critical subcontractors and vendors. The POM should then include any up-front funding requirements to cover out-year cancellation charges for recurring costs.

2. Identification of materials and components that are common to more than one program and which could practically be acquired under a single acquisition contract and provided as government-furnished material.

3. Identification of materials and components that should be prestocked in a buffer inventory in semifinished condition to enhance the program and logistics managers' ability to surge production to meet a variety of potential industrial base contingencies ranging from international materials embargoes and domestic labor strikes to an intense military conflict.

4. Identification of value engineering opportunities where less expensive materials could be substituted without loss in weapon system performance.

Subcontractor/Vendor Base

1. Identification of those locations in the subcontractor/vendor base where DOD is forced to rely on sole domestic and foreign sources and the reasons for such situations.

2. Identification of those cases where prime contractors should be directed under DAR 3-216 to use dual sources or where it is necessary to direct the prime to use a specific source in order to maintain a critical domestic production capability.

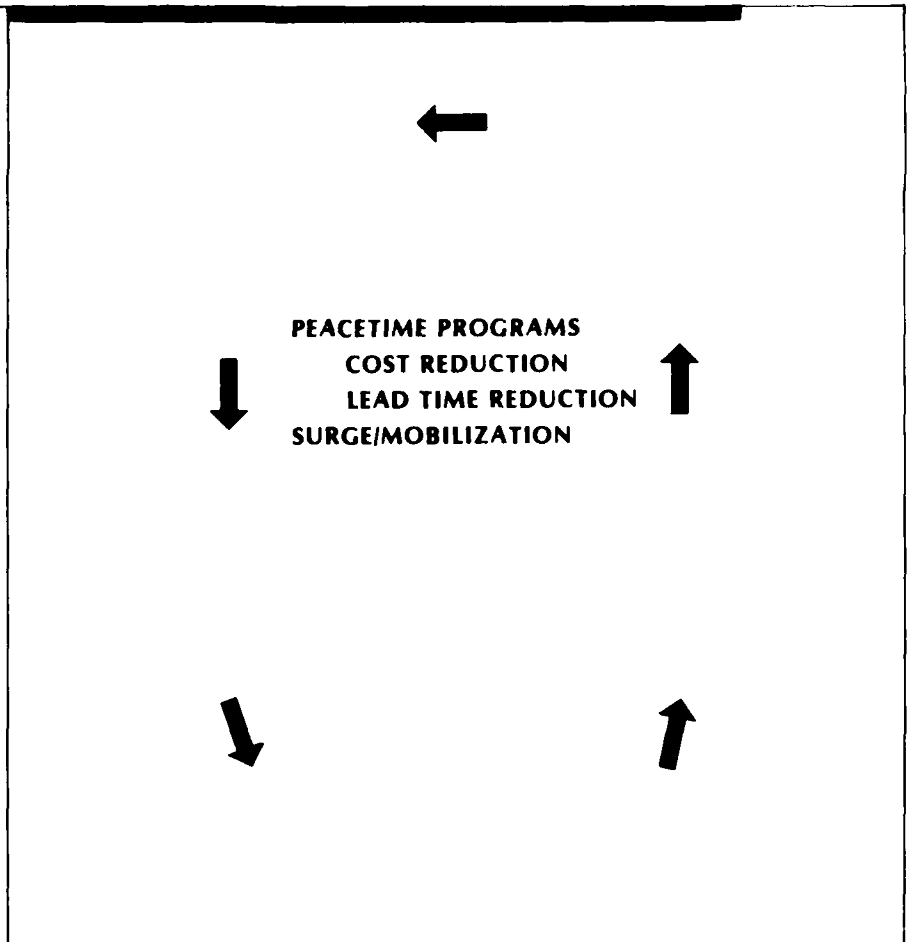
Plant Capacity

1. Identification of annual production rates that best contribute to optimum plant capacity utilization and the impact on program unit costs and lead times.

2. Identification of plant rearrangement and productivity-enhancing capital investment alternatives (for both government-owned and privately owned production assets) for reducing program costs and lead times. These alternatives should be expressed in terms of each alternative's contribution to both cost efficiency and surge objectives. The selected alternative should also discuss which contractual strategies are the most appropriate, e.g., a formal Tech Mod project vs. a simpler award fee arrangement.

3. Identification of that domestic production capacity that could be effectively transformed to support a mobilization contingency.

he final product of each annual planning effort should be the prioritization of proposed industrial base projects and the analysis of each proposal in terms of program cost and lead time reduction under peacetime conditions and/or improvement to required surge/mobilization production capabilities. Figure 1 provides a pictorial description of the annual planning cycle that the Air Force currently plans to use.[13] Each planning cycle should begin with (step 1) the initial definition of unresolved industrial bottlenecks from the previous planning cycle and the identification of economic and financial trends obtained from available data bases. A combination of in-house and contractual planning studies as defined above should then be accomplished (steps 2 and 3) to develop corrective industrial base projects. The completion of IBPs by program managers should be accomplished during steps 2 and 3 of the planning cycle. After the appropriate cost and lead time reduction options relative



to both industrial base projects and program acquisition strategies have been included in PBA (step 4), approved projects and acquisition strategies should then be incorporated into the appropriate budgetary documents and program directives (step 5).

The planning should support the individual weapon system program manager by integrating those acquisition strategies and industrial base projects that possibly cut across numerous defense and commercial product lines at the plant (prime and sub-tier) level to reduce peacetime program costs and lead times. The identification of appropriate acquisition strategies relative to the materials and capacity management planning objectives should focus on those strategies that enhance business base stability and productivity growth. Business base stability strategies include the identification of multiyear procurement opportunities for an entire weapon system as well as for critical components or pieces of supporting government-furnished equipment. Business base stability can also be enhanced by the application of not only optimum program production rates, but also the allocation of production rates among competing programs within a given plant to optimize overall plant utilization.

The two primary contracting tools available to achieve optimum plant capacity utilization are the DAR 3-216 negotiation exception and the prime contractor's make-or-buy program. The DAR 3-216 negotiation exception permits the contracting officer in the system program office to negotiate with specific contractors to maintain "an industrial mobilization base which can meet production requirements for essential military supplies and services."

his negotiation exception has been used primarily in the past to support munitions programs by maintaining one or more planned producers (prime contractors) at minimum sustaining rates based on cost trade-offs against war reserve materiel inventory objectives. Since the maintenance of efficient operating rates during peace-

time is critical to the efficient acquisition of the Five-Year Defense Program and the effective transitioning to a surge/mobilization posture, this DAR negotiation authority is the one contracting tool currently available that can significantly enhance DOD's ability to implement the new DOD productivity and preparedness policies. Its prudent use offers the potential for not only incentivizing the desired market structure in terms of peacetime plant capacity utilization and modernization, but also the maintenance of appropriate levels of excess production capability for surge and mobilization, and the creation of required levels of competition at the sub-tier levels using the prime contractor's make-or-buy program.

While it is desirable to think of the U.S. aerospace industry as being responsive to the free-enterprise system and receptive to unlimited competition, the economic reality is that it is not.[14] The long-term impact of the Defense Department's stimulus to the industry in terms of increasing regulation, profit limitations, and business base instability has been an industry response in terms of conciously planned growth into other markets to minimize the overall impact of defense business on corporate financial performance. Another corporate strategy has been the conscious shift of work from in-house to the subcontractor base to shelter the prime contractor against the risk of program instability.[15] After all, it is much more appealing to cancel a subcontractor than to lay off workers or divest physical capacity in the event of a program cancellation or significant program reduction. However, as a major production program phases out of production, the tendency still exists to pull work back in-house from the subcontractor/vendor base to stabilize internal capacity utilization as much as possible.

The missing link is the degree to which corporate decision-makers will be willing to integrate their corporate strategic planning activities with the proposed defense industrial planning activities. The importance of future technology developments and industrial resource availability to long-term national security is obvious. Therefore, it is essential to improve long-term government/industry planning interfaces; because, while "technology is the engine for managing the transition from the present to the future, strategic planning is the guidance system."[16]

Conclusions and Recommendations

In conclusion, the establishment of a credible industrial planning system should be viewed as a means to an end, not an end in itself. The planning system should be one vehicle for integrating policy and program acquisition decisions to accomplish the goal of efficiently and effectively acquiring the DOD peacetime program, as well as the objectives relating to the maintenance of viable surge and mobilization production capabilities. The long-term success of the industrial planning function will depend to a large extent on the ability of the overall weapons acquisition process to effectively integrate the planning functions and the acquisition/contracting functions—both on the government and industry sides.

he long-term result of effectively integrating an industrial planning program with ongoing force and technology planning programs will be the development of strategic plans that identify those levels of production capacity that should be efficiently maintained. Using the AFSC Vanguard process as a model, technology and force planning can be visibly integrated with the proposed industrial planning process. The long-range industrial planning would flow from identified threat scenarios and identified bottlenecks and constraints for strategic manufacturing resources (Figure 2). Based on identified out-year production capability shortfalls (using available long-range procurement plans like the Five-Year Defense Program), an environmental assessment of projected economic, political, and technological factors would be required to match the projected manufacturing resource base with production requirements for both peacetime and wartime force structures.[17] The environmental industrial resource assessment should be compiled using economic forecasting services that are commercially available, e.g., Data Resources Inc., Wharton, or Chase Econometrics. In addition, the assessment should be prepared far enough in advance so that it could be used by program managers in preparing their proposed annual IBPs.

The need for the environmental assessment of out-year economic planning baselines is clear. The question is, who would be responsible for preparing the assessment in a timely manner? A recommendation from numerous past studies (the most recent being the HQ AFSC Affordable Acquisition Approach Study) has been the creation of "a long-range planning group" either centralized at the DOD level or decentralized within one of the military departments. A fundamental task of such a group could be the annual preparation and dissemination of the environmental assessment for use by the services in preparing their annual IBP plans and PBAs.

From the long-term planning standpoint, the outputs from the environmental assessment would represent inputs to identified developmental goals and proposed program actions (e.g., manufacturing technology) to resolve identified shortfalls in the out-year manufacturing resource base. Furthermore, since business uncertainty is related to the institutional instability in the DOD budgetary process, the presence of a long-range industrial resource planning process should in itself reduce the perceived business uncertainty of the overall acquisition cycle to a certain extent. Furthermore, the actual availability of credible industrial planning information may act as a disincentive to the adjustment of short-term budgets where the adjustments can be readily translated into long-term program cost growth or reduced strategic responsiveness.

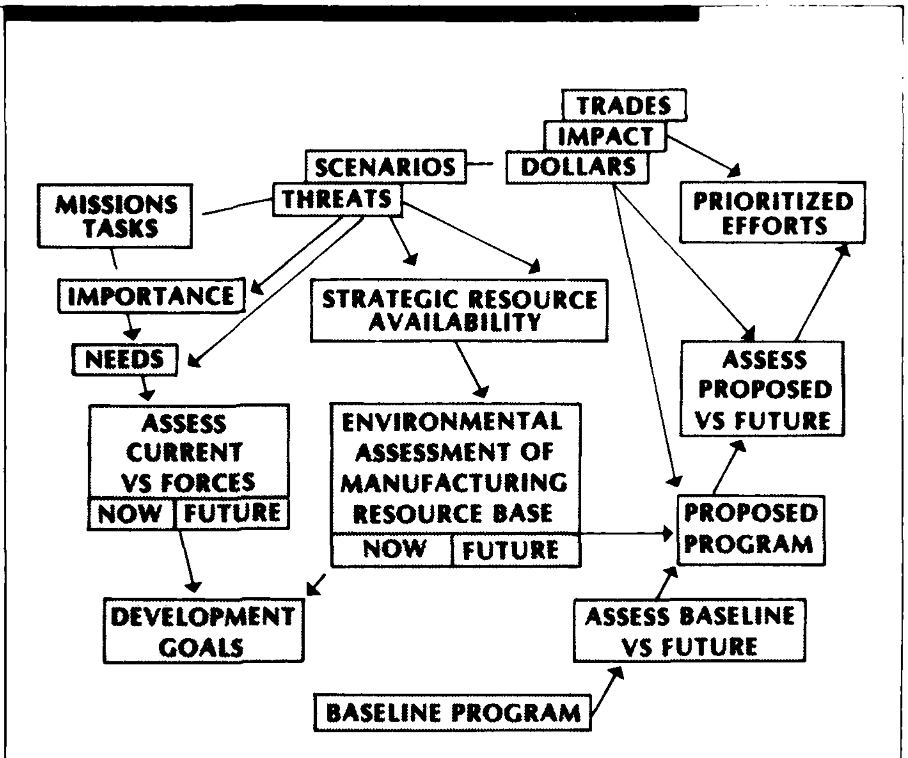
For the industry side, changes in strategic planning logic are required. Inefficient government-owned production assets will be disposed of; therefore, contractors currently possessing these assets should buy these assets and modernize them or be willing to dispose of them. Since 50 to 60 percent of weapons production costs are normally incurred by subcontractors and vendors,[18] future weapon system acquisition strategies should focus on the establishment of multiple sources, especially at the subcontractor levels, to maximize the economic benefits of competition. The message that should be com-

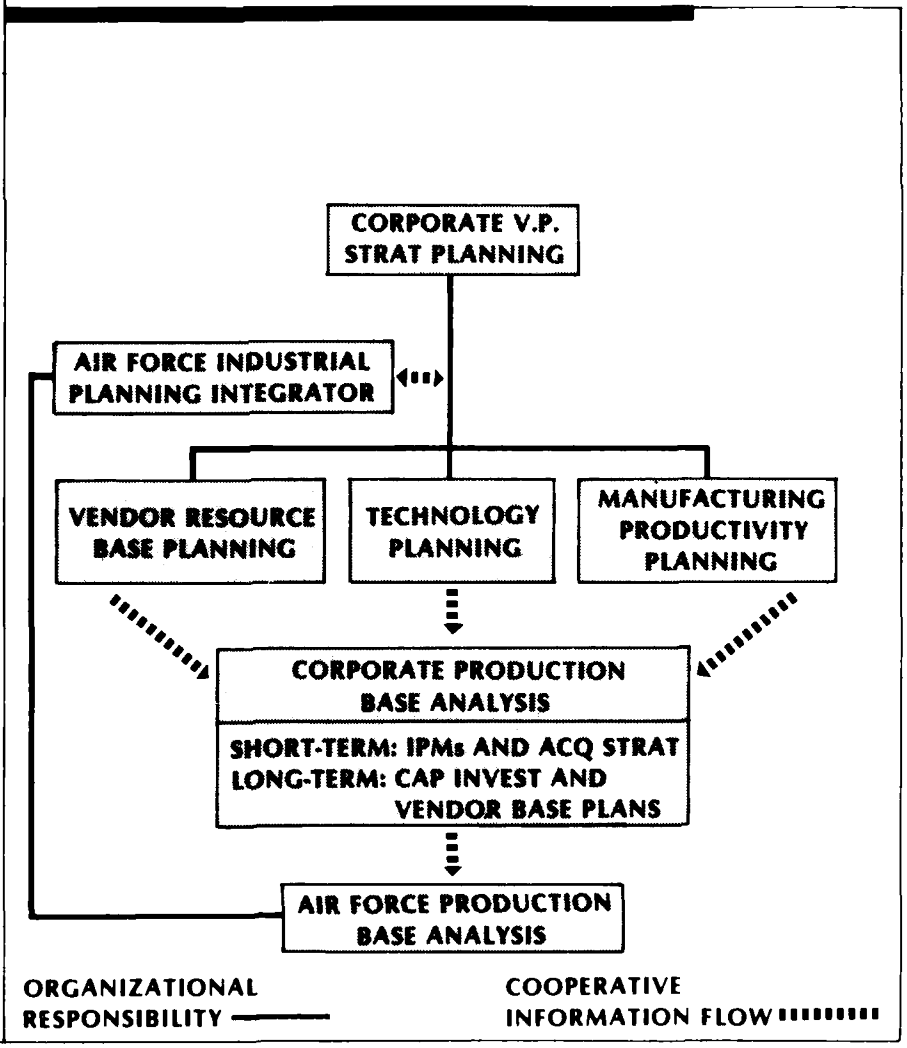
municated to industry through the source-selection and contract-award processes is that only efficient and productive capacity will be sustained over the long term.

possible joint DOD/industry organizational approach is presented in Figure 3 to integrate DOD and proprietary corporate strategic planning objectives regarding the U.S. manufacturing resource base. The "industrial planning integrator" could either be assigned to a local contract administration organization or to the program manager's staff. In either case, he/she would be responsible for supporting the preparation of specific IPBs for those program managers relying on a given contractor's production resource base. Applicable proposals from each IBP would then be incorporated into the appropriate service's PBA. The industrial planning integrator could also perform as the linking pin between specific weapons program or contract administration offices and the above suggested long-range planning group.

The options for DOD policymakers to incentivize long-term acquisition efficiency and provide short-term production surge capability are becoming increasingly constrained. The potential for 100 percent progress payment rates that currently exists under the flexible progress payment policy provides an upper limit on the amount of cash flow that can be generated by defense contracts. The changes in profit policy since 1977 to incentivize capital investments have not only been ineffective in actually increasing realized profits, but have also not generated increased productivity-enhancements by the major defense contractors.[19] Also, for the large defense contractors, defense contracts are now generating much higher returns on assets for equivalent returns on sales than for corresponding commercial work.

Finally, there is an awakening among some DOD leaders that the inherent macroeconomic purchasing power of the defense acquisition dollar should be used as the carrot to incentivize an efficient aerospace market structure for future defense-related acquisitions rather than to continue the practice of focusing on





ineffective, piecemeal changes to departmental contract clauses.[20] The challenge for both industry and defense leaders is clear—the redirection of currently diverging long-term objectives. While the proposed industrial planning mechanism is clearly complex, it may be the only reasonable approach to ensuring the long-term strategic availability of those domestic production and technological resources required to efficiently and effectively support long-term national security objectives. ■

Notes

1. Dr. John J. Kennedy, "What the Research on Incentives Reveals on the Nature of the Cost Growth of Complex Systems," a paper prepared for the Annual Cost and Pricing Symposium of the Institute of Cost Analysis, Washington, D.C., December 7, 1982, p. 7.

2. *Ibid.*, p. 7.

3. Department of Defense Directive 4005 1, July 28, 1972, pp 1 3

4. "Affordable Acquisition Approach (A^3)," A Study by HQ Air Force Systems Command, February 9, 1983, p. ES-5.

5. Jacques S. Gansler, *The Defense Industry* (Cambridge, Mass.: The MIT Press, 1980), pp. 128-161.

6. General Alton D. Slay, USAF, "The Air Force Systems Command Statement on Defense Industrial Base Issues," statement before the Industrial Preparedness Panel of the House Armed Services Committee, November 13, 1980, pp. V-1-V-3.

7. Dr. Andrew P. Mosier, "Improving Industrial Productivity," *Program Manager*, Vol. XI, No. 6, November-December 1982, pp. 10-14.

8. W. Skinner, "Boosting Productivity is the Wrong Focus," *Wall Street Journal*, March 15, 1982.

9. Colonel Ron Carlberg, USAF, "New Policy Directions for International Acquisition," briefing to the Aeronautical Systems Division Pricing Symposium, Wright-Patterson AFB, Ohio, June 1982.

10. Ronald L. Schill and David V. Lamm, "Strategic Management of Resource Markets," Naval Postgraduate School, April 1982, pp. 44-54.

11. Barry Bluestone and Bennett Harrison, *The Deindustrialization of America* (New York. Basic Books, Inc., 1982), p. 107.

12. Lieutenant Colonel O. M. Collins, USAF, "Can the Pentagon Use Its Purchasing Power to Improve Industrial Responsiveness in the US Aircraft Industry?" Air Command and Staff College, Report No. 0545-81, May 1981, p. 44.

13. Fiscal Year 1983 Air Force Production Base Analysis (Completed Jointly by HQ AFSC and HQ AFLC), April 1983, p. 2-3.

14. Gansler, p.1.

15. Shill and Lamm, p. 362.

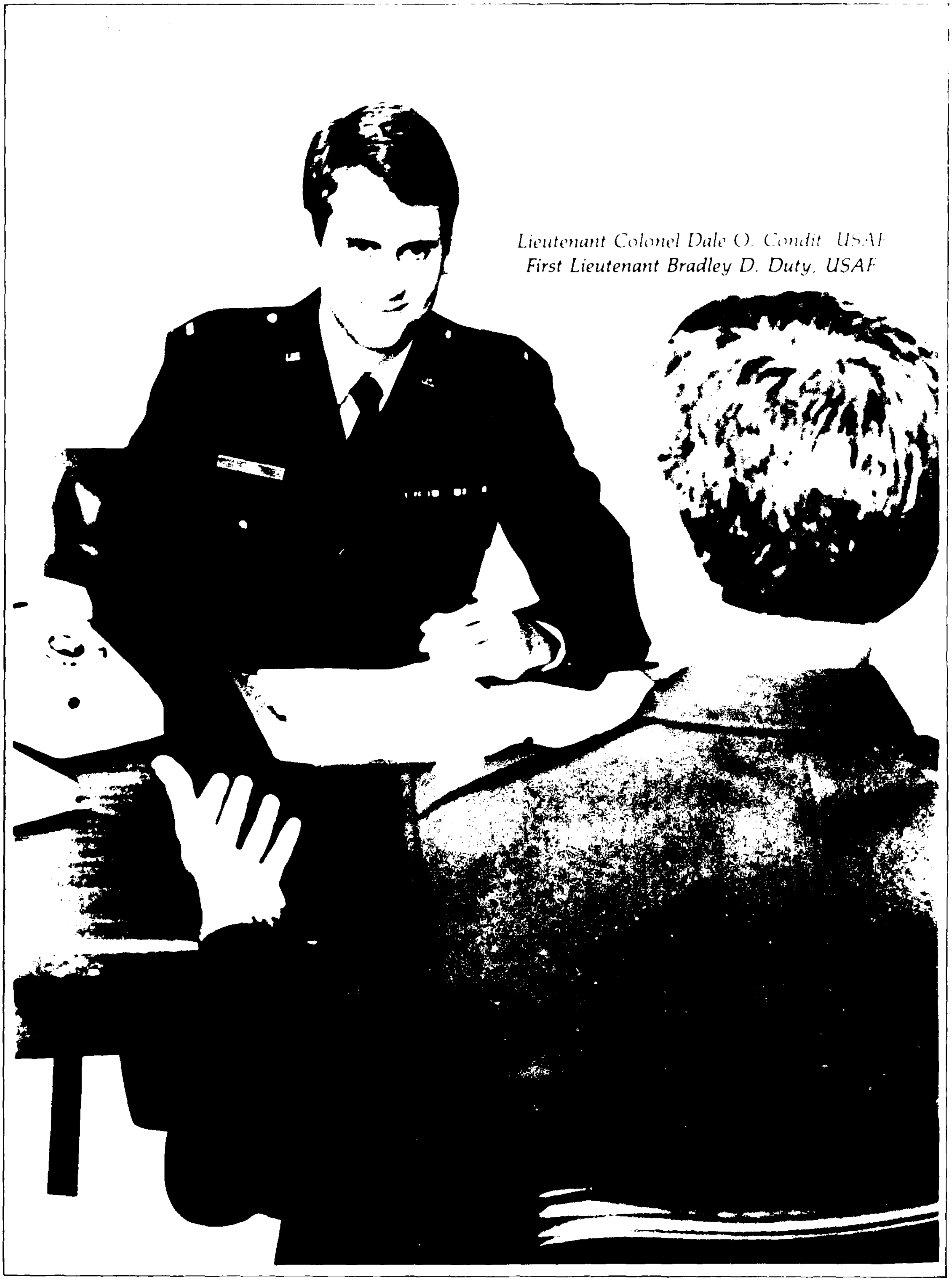
16. D. Bruce Merrifield, "The Business Environment Ahead—And How to Handle It," *CHEMTECH Magazine*, June 1982, p. 345.

17. Shill and Lamm, pp. 375, 381-401.

18. "Defense Subcontractor/Supplier Industrial Base (An Assessment of Industry Recommendations)," Headquarters, Air Force Systems Command, December 1981, p. 1.

19. "Profit Study '82 (Summary Report)," HQ Air Force Systems Command, April 1983, p. 53.

20. Gansler, pp. 283-284.



Lieutenant Colonel Dale O. Condit, USAF
First Lieutenant Bradley D. Duty, USAF

Few, if any, of the tasks of supervisors or senior officers are as important as the task of counseling younger officers. Particularly important is that first session a superior officer has with a new second lieutenant at his or her first duty-assignment. All too often, it is little more than a brief session in which the office functions are discussed and the co-workers are introduced.

With most bases offering "inbound" briefings and a "sponsor" program, many supervisors forget that several areas need to be emphasized to these new lieutenants, and that these areas are best discussed by the military supervisor or the senior military officer in the immediate organization.

While no specific set of topics for this discussion has ever been established, the meeting should set the stage for the beginning of the officer's career, whether it turns out to be 4 years or 20 or more. We offer the following topics for consideration, and encourage you to use them—or others like them.

The First Emphasis: "You are an officer"

Because of current trends within the military toward "occupationalism" caused by the need for certain critical skills, the new lieutenant must be reminded that, first, we are professional officers. As such, we have a rich heritage to sustain us and specific mission responsibilities to fulfill. The new lieutenants should be made to realize that they have a duty to be professionals, with the proper wear of the uniform and extending to their work in the organization and beyond, to all their activities, both on and off the job. Stress that as professionals they must always take responsibility for their actions and for the actions of their subordinates.

The Role of the Organization

We often assume incorrectly that young lieutenants know the role of the organization to which they are assigned. We would be well advised to review these roles with them, if only briefly, starting with the role of the service itself. While the mission of the service may seem obvious, putting it forward in our own words is useful to these new officers, offering them a perspective not apparent in manuals and textbooks. Then there should be an explanation of the major command's mission. Next, the role of the intermediate organization should be discussed. Finally, the role of the lieutenant's immediate organization should be explained, in somewhat more detail than the others.

You may think all this is quite unnecessary, but you would be surprised how many young lieutenants are only vaguely aware of the roles and missions of most of these organizations, and this lack of awareness increases as they get closer to their immediate organization. Furthermore, such discussion puts the lieutenants' jobs in the context of the total mission—why they are doing what they do.

Chain of Command

Along with the above discussion, the new lieutenants should be apprised of their chain of command. This will clarify for them their place in the organization. Make clear to them the value of the chain of command, and be sure they understand its proper use. It can also be useful to discuss line and staff responsibilities within the organization.

What is Required of the Officers Assigned to the Immediate Organization?

This discussion will focus on your specific organization. While the emphasis will be on the types of tasks to be accomplished, you should also discuss the need for hard work, the expectation that one will carry his share of the load, and the sacrifices that are sometimes required. Be candid with these individuals so that there will be no misconceptions about what their new jobs entail. You might also warn them of any common pitfalls plaguing young officers in your organization.

What Else is Expected of an Officer?

We must also talk to these young people about the additional responsibilities required of officers. Some of this discussion may be organization-specific, but it may also include such things as the importance of joining the officers' club, taking part in social functions, and accepting their share [illegible] should be told of the importance of participating in the various service activities to which they will be exposed. We also believe they should be strongly encouraged to take part in the activities of their local community which is not only rewarding in itself, but serves as well to enhance the image of the service and the military in general. Such activities help ensure the development of the mature perspectives and qualities that are important in officers.

What is Required to be Effective—and Successful?

Everyone has his own ideas about the answer to this question but, we have narrowed our answer to five items.

First, encourage new lieutenants to use initiative; that is, don't always wait to be told to do what needs to be done.

Second, as quickly as they can, they must learn as much as possible about their jobs and organizations. It's important to do this quickly, because the time available to learn disappears soon after they actually begin doing their jobs. Tell them not to be afraid to ask questions.

Third, encourage them to seek new and increased responsibilities, so as to become mature professionals more quickly.

Fourth, make them aware of the educational opportunities available, and encourage them to take advantage of them.

Finally, stress the importance of career planning. If they are to be successful, they must acquire the breadth and depth of experience required to assume the responsibilities of senior officers. Planning their career also provides these young officers with milestones to shoot for, and a means by which to measure their progress.

(Continued on page 47)

■ *Lieutenant Colonel Condit is Deputy Systems Program Director for the Groundwave Emergency Network (GWEN) program, Electronic Systems Division (AFSC), Hanscom AFB, Mass. First Lieutenant Duty is a Minuteman Missile Combat Crew Commander at the 341st Strategic Missile Wing, Malmstrom AFB, Mont.* ■

Looking for a Better Idea

Alan W. Beck

Value engineering for government contractors is basically a suggestion program where those contractors share in the cost savings resulting from a contractor-originated suggestion called a value engineering change proposal (VECP). The contractual incentive for shared savings can motivate contractors to aggressively seek and submit potential cost reduction ideas. Value engineering is also done by government agencies, which perform analyses to find ways to make things better—cheaper, longer life, less repair, etc.—but this discussion is aimed only at government contractor incentives and obligations under value engineering clauses. Value engineering clauses may either be "incentive" or "program requirement" clauses.

Under the incentive clause, value engineering is optional for the contractor. He may perform value engineering analyses and submit VECPs if he feels the incentive of shared savings is sufficient.

Under the program requirement clause, the contractor is required by the terms of the contract to conduct a value engineering program. The statement of work is written to *require* value engineering, and the contractor must propose and furnish specified value engineering effort. Because it is a contract requirement, this value engineering effort is an allocable cost to the contract.

■ *Mr. Beck is a Professor of Industrial Engineering in the Business Management Department, School of Systems Acquisition Education, at DSMC.* ■

Contractors may share in several categories of acquisition savings for value engineering changes to include the following:

—*Instant contract savings*. Net cost reductions against the contract under which the VECP was submitted;

—*Concurrent contract savings*. Measurable net reductions in other ongoing contracts;

—*Future contract savings*. Savings for future units not yet on contract, including multiyear contract items not yet funded; and

—*Collateral savings*. Agency net cost reductions exclusive of acquisition savings, i.e., changes in the costs of maintenance, logistics, etc.

As shown in the accompanying chart (from Federal Acquisition Regulation 48.104.1) the percentage share a contractor receives for VECPs varies depending on the contractor cost risk and type of contract. Collateral savings, not shown in the chart, are generally shared at 20 percent of average yearly collateral savings, not to exceed $100,000. Savings are paid by a firm-fixed-price line item on the contract.

When to Use

Value engineering is required in contracts over $100,000—or less if the contracting officer sees a potential for significant savings. Value engineering is generally appropriate for supply (full-scale development or production) contracts, the exception being contracts for commercial products.

Subcontractors are encouraged to participate in value engineering by mandatory inclusion of value engineering provisions in subcontracts.

The Federal Acquisition Regulation (subpart 48.2) requires a value engineering clause in solicitations and contracts over $100,000, but there are several exceptions. For example, in some contracts, the contractor should, as a matter of course, work for more economical methods. Such contracts include those for (1) research and development other than full-scale development, (2) engineering services from non-profit/not-for-profit organizations, (3) personal services, and (4) product or component improvement. Value engineering is generally not appropriate for such contracts, and special justification is required before a value engineering clause can be included.

Spare parts and repair kits offer high potential for value engineering savings. The August 29, 1983, Secretary of Defense memorandum on spare parts acquisition recognized this potential and directed use of the value engineering incentive clause in spare parts or repair kits of more than $25,000 for other than standard commercial parts.

The program requirement clause should be used when program managers want to ensure a certain contractor value engineering effort, such as in a major system full-scale development program. Otherwise, the incentive clause should be used.

Application Considerations

A climate of enthusiasm and support for value engineering has been building within DOD from the top policy levels as reflected in a new VE awards program, emphasis from competition advocates, and the

Government/Contractor Shares of Net Acquisition Savings

(FIGURES IN PERCENT)

CONTRACT TYPE	SHARING ARRANGEMENT			
	INCENTIVE (VOLUNTARY)		PROGRAM REQUIREMENT (MANDATORY)	
	INSTANT CONTRACT RATE	CONCURRENT AND FUTURE RATE	INSTANT CONTRACT RATE	CONCURRENT AND FUTURE CONTRACT RATE
FIXED-PRICE (OTHER THAN INCENTIVE)	50/50	50/50	75/25	75/25
INCENTIVE (FIXED-PRICE OR COST)	*	50/50	*	75/25
COST-REIMBURSEMENT (OTHER THAN INCENTIVE)**	75/25	75/25	85/15	85/15

*SAME SHARING ARRANGEMENT AS THE CONTRACT'S PROFIT OR FEE ADJUSTMENT FORMULA.
**INCLUDES COST-PLUS-AWARD-FEE CONTRACTS.

Secretary's emphasis on improving acquisition practices. This top management support, coupled with success stories from the field, is increasing interest in value engineering.

In the past, many government people were not enthusiastic supporters of value engineering. Some felt it is an incentive for contractors to present a poor design initially in order to win big savings later through VECPs. Where competition is effectively used, this potential difficulty is largely overcome. Some government people, schooled through years of frustrating experience with the costly side effects of changes, are biased against any change in the contract. Others fail to see the positive spin-offs in quality and reliability, such as where VE effort might identify potential for use of standard, off-the-shelf parts. The natural opposition to change could perhaps be influenced by the knowledge that it is often very difficult to estimate and negotiate value engineering changes. Some worry that estimated future savings may never materialize if other changes occur. Lack of enthusiastic support can cause government personnel to discourage, or at least not encourage, value engineering change proposals.

ontractors also react to past experiences and to management's encouragement (or lack of it). The opportunity for significant financial gain not subject to profit or fee limitations is attractive, but company managers may not approve spending company money on an incentive VECP if the company feels the government may not accept it. As contractors perceive that government managers are serious about value engineering, the strong financial incentive to share savings should result in an increased number of VECPs.

Cost Implications

Since the program requirement clause is a part of the statement of work, the cost of the program can be seen as the scope of the effort is proposed and defined. Under the program requirement clause, if significant potential exists for more economical performance through value engineering efforts, the buying agency may "save" part of this cost. This is because the contractor's share percentage is lower under a program requirement clause than under an incentive clause.

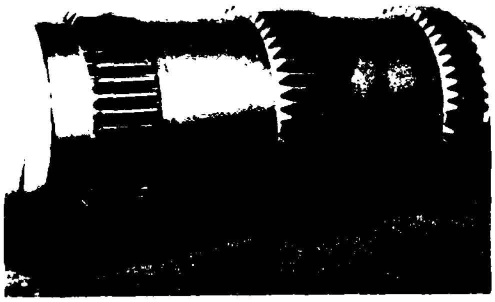
The type of contract is also a driver in the contractor's share of cost savings for value engineering. The government retains a bigger share of savings if a cost-type contract is used. Under incentive contracts, the sharing of savings is determined by the contract share line. This recent change means there is no need to negotiate detailed changes to target cost, target profit, and ceiling price established in the contract. Also, there is less need to worry about the accuracy of the estimated savings, because the contractor realizes his savings by ending up with a lower overall cost, the final profit being determined by the share line.

The value engineering incentive clause is not supposed to cost the government anything because contractor resources are used to develop and submit VECPs. However, development costs not charged to a particular contract may be allowable charges to overhead as bid-and-proposal effort; thus, the charge would be spread across all contracts serviced by that overhead pool.

A significant cost consideration to the program is the possibility that the VECP may require *more* money in the short run to pay for a change that will result in future savings. For example, additional spending may be

Reclaiming CH47 Helicopter Vertical Shafts

— Pitted and corroded shafts classified unserviceable
— Replacement cost: $70,000 per shaft

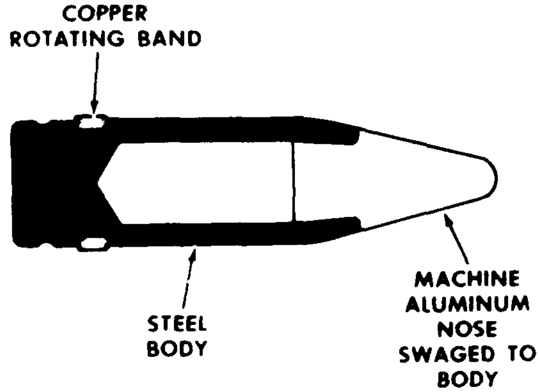


— VE study developed special procedure to repair pits and corrosion
— Reclamation cost: $5,660 per shaft

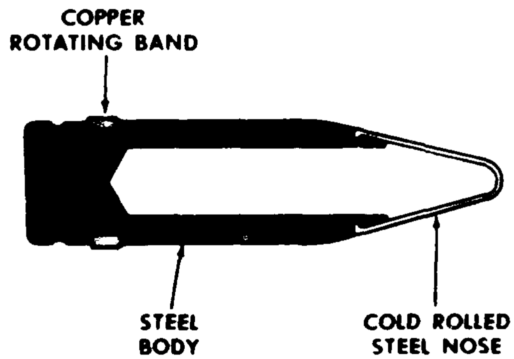
Type: Army-generated
Responsible Army Command: Depot Systems Command (New Cumberland Army Depot)
Cost Savings: $7.5 million (first year)
Return on Investment: 11 to 1

■ *An example of the results of the Army's extensive in-house value engineering effort, which produced $350 million in net savings and cost avoidance in FY 83.* ■

Change to 20mm Target Practice Projectile



— Solid aluminum nosepiece used in target practice round
— Expensive machining process



— Hollow steel nosepiece
— Less costly forming process
— Cost savings per projectile: $.06

Type: Contractor-generated value engineering change proposal

Contractor: Galion Amco, Inc.
Responsible Army Command: Armament Materiel Readiness Command
Cost Savings: $1.7 million
Return on Investment: 20 to 1

■ *The contractor element of the Army's value engineering program resulted in 923 VECPs during FY 83, which represented more than $350 million in net savings.* ■

required to design and produce an item that is more reliable and maintainable—and therefore less costly—than that specified in the contract. In this case, instant contract "savings" may be negative, and the program manager may need to request more money.

I have attempted here to give you the fundamentals of value engineering. It is a tool with great potential for reducing costs while improving reliability and support of equipment. If applied and encouraged sensibly, value engineering could be one of the keys to a successful program.

to the Software Problem

Joseph McCarthy

uring the early to mid-1950s the programmable electronic digital computer started its migration out of the laboratory and into the world of practical application. By today's standards these devices were unsophisticated, costly, heavy, temperamental, and energy-hungry. In spite of all of these drawbacks, the computer found its way into our weapon systems before the close of that decade. From that period to the present there has been a continuing struggle within the Department of Defense (DOD) community to provide the software to drive these computers in a fashion that satisfies the preconceived requirements, and does it for a stipulated amount of money and in a specified period of time. More often than not the struggle was lost. Today we are on the threshold of major improvements in this long-neglected area.

The United States cannot always meet the challenges of its adversaries on the basis of numerical superiority. We must frequently depend on the sophistication of our weapon systems to provide us with sufficient advantage to secure our national defense. Practically every significant modern weapon system relies on software for performing critical functions related to its mission or operation. This reliance on embedded software is growing and will continue to grow, because the demand for increased functionality will continuously expand. A secondary factor in this growth is the progress that has been made and continues to be made in digital computer hardware.

■ *Mr. McCarthy is a Group Head in the Software Systems Directorate at Grumman Aerospace Corporation.* ■

Each year we are introduced to new computers that are less expensive, more reliable, smaller, and more energy-efficient than those of the previous year.

The increased demand for digital computer systems magnifies the problems prevalent in the embedded software development process. There is a well-documented trail of systems that did not meet their performance expectations and/or experienced cost and schedule overruns and/or were difficult to maintain and modify. In almost every case, these problems can be traced to poor requirements definition, weak management discipline, the inherent size and complexity of the system, or the critical shortage of qualified software professionals—or some combination of the four.

Software is unique in many respects, particularly in that the end product of all of our efforts is intangible. Frequently, all we have to attest to its existence is a scrap of paper covered with the computer jargon of the professional programmer/analyst. The "invisible" nature of software fosters a management er[illegible]ment where the coding process is "90 percent complete" for half of the total coding time, and the debugging process in "99 percent complete" most of the time.

he difficulty in managing software projects is probably best demonstrated in the report to Congress made by the Comptroller General in November 1979. This report examined nine software projects with a total acquisition cost to the government of $6.8 million (see Figure 1). Of this amount, 47 percent was never successfully used; 29 percent was never delivered; 19 percent was used with major rework; 3 percent was used with minor change; and less than 2 percent was used as delivered. All of these projects had one common failing—poor management.

In addition to the difficulties experienced in managing software, there are problems generated by the increased sophistication of the emerging systems. In the past, a digital system was required to provide the operator with the data needed to make a decision. Today's systems not only gather and analyze the data, they make the decision and act on it. The heuristic methods that are necessary to implement these increased capabilities result in software that is both complex and extensive. A malfunction in today's software is quite capable of placing both men and equipment in jeopardy (e.g., a flight control system for an unstable aircraft).

The growth and size of some typical systems can be seen by using on-board memory as an indicator of the amount of software needed to drive the system (see Figure 2). During the mid-1970s the Navy's E-2C had less than 100,000 words of memory. Today this same aircraft has over 1 million words. The E-3A boasts 4 million words of on-board memory, while the F-18 and the EF-111A trail with 600,000 and 200,000, respectively.

These large systems are fabricated by using software modules averaging

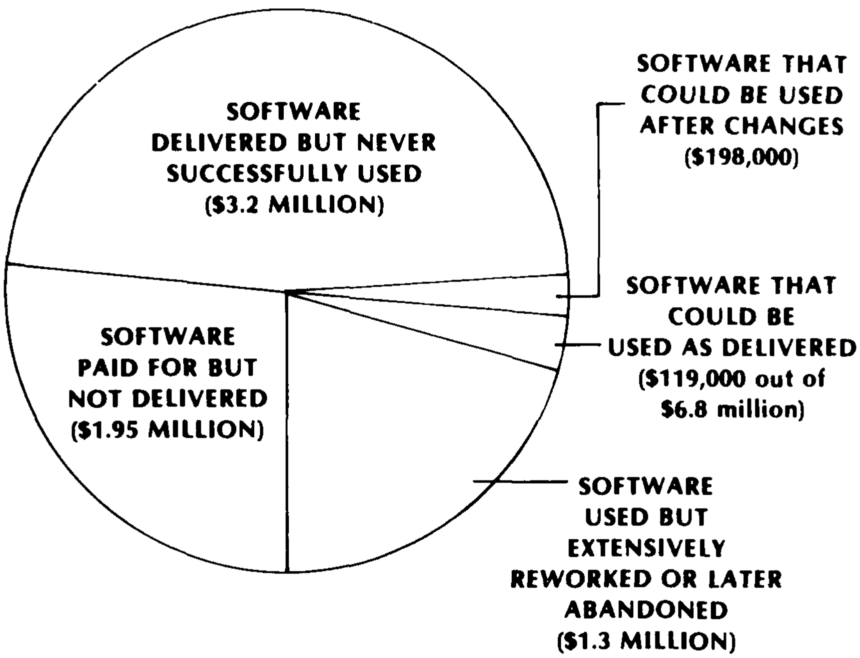
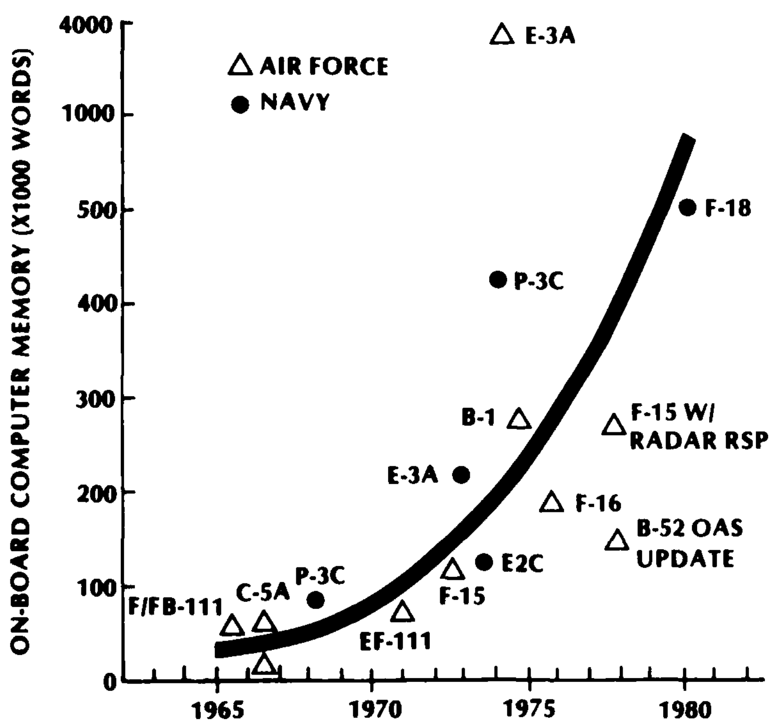


Figure 2. Growth in Military Aircraft Software Requirements

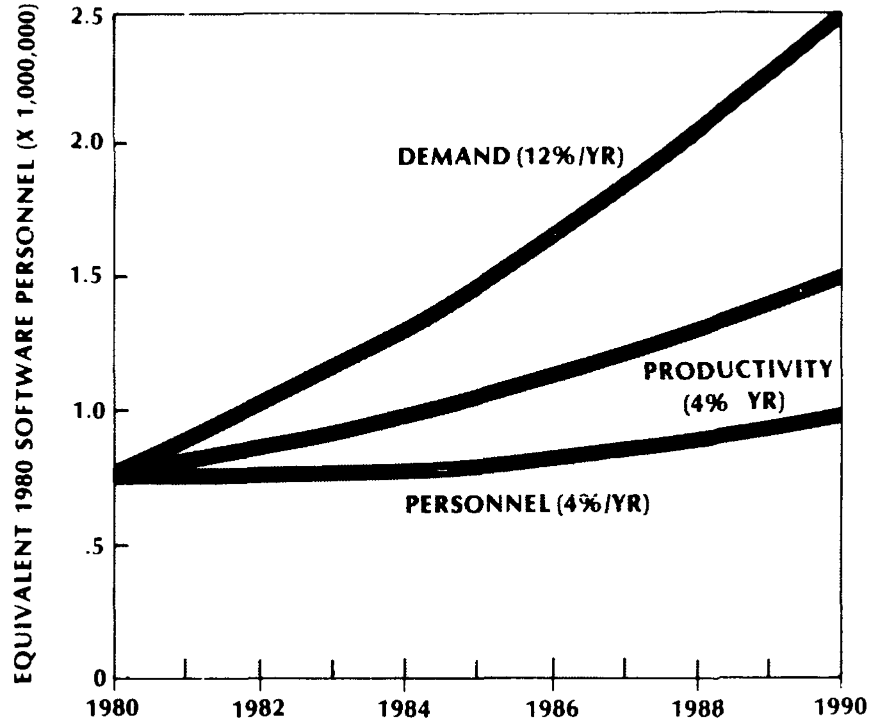


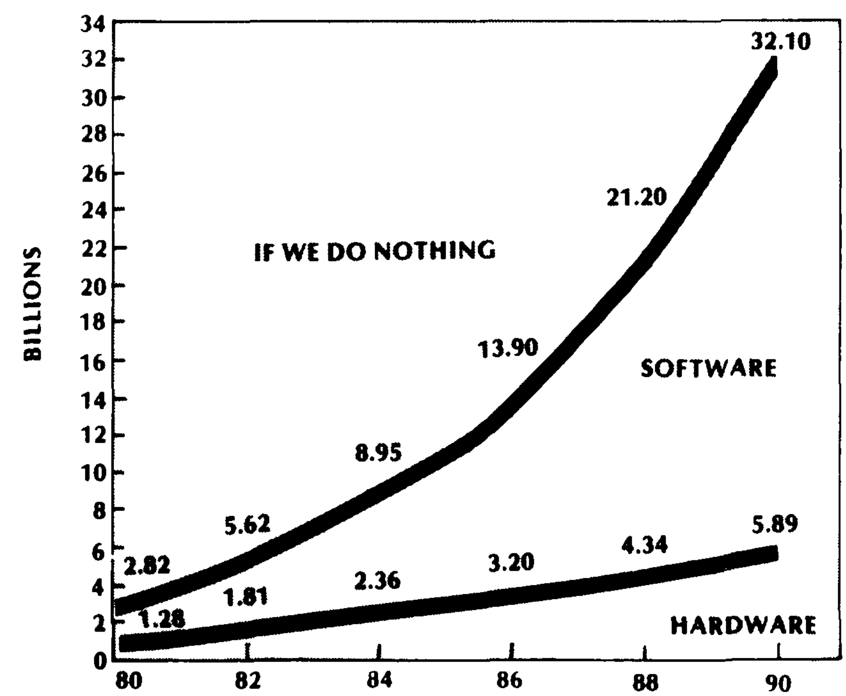
100 lines of code each. A typical system may have several hundred to a thousand modules, while the very large ones contain several thousand modules. Each module has its own input, processing, and output requirements. Through its input and output, it interacts with one or more other modules. The relationship becomes more complex as more modules are added to the system, with a number of possible interactions increasing as an exponential function.

The growth of software brings with it an increase in the number of trained professionals required to staff a project. Unfortunately, the relationship is not linear. As the size of the staff increases, the individual productivity of the software personnel decreases. This is because of the increase in intercommunication that is necessary to coordinate the total effort and an increase in the number of sequential constraints. A sequential constraint usually takes the form of "Task Y cannot be started because Task X is not complete." The number of constraints is clearly a non-linear function of the number of tasks.

We also have to face the fact that there is a shortage of trained software professionals in this country. The gap between the need and the supply shows no sign of abating. It is, in fact, widening (see Figure 3). The United States ranks fourth in the world in scientific literacy—the Soviet Union ranks first. In the time period 1968–1978 the Japanese increased the number of graduates in scientific fields by 62 percent. During that same period, in the United States there was a decrease in the number of scientific graduates by 13 percent. Industry spends 50 to 70 percent of its personnel dollars on salary, but less than 1 percent on training.

The preceding tales of woe are not new, nor have they gone completely unchallenged. There have been past efforts, and there are current efforts that strive to better control the entire process by which software is provided. If a single word were sought to describe these efforts, however, that word would have to be "uncoordinated." Each of the services has made its own attempts for its own reasons. The Army has its Software Development Support System (SDSS), the Air





SOURCE: ELECTRONIC INDUSTRIES ASSOCIATION.

Force has its AVSAIL Laboratory with the Integrated Support Software System (ISSS) and the Navy has its Facility of Software Production (FASP) and its Software Support Facility (SSF). The computer vendors offer a variety of software tools that assist in the production process, but their principal interest is selling computer hardware. There are even companies like Softool and Higher Order Software (HOS), which were formed specifically to market software products for this purpose. The major DOD contractors are also active as a matter of self-preservation. Bell Laboratory has been using the Programmers Work Bench (PWB); Grumman Aerospace developed the Software Life Cycle Development (SOLID) System; Boeing has ARGUS; Ford Aerospace uses the Development Support Machine (DSM) concept; and Hughes has DAS, AIDES, and SDS.

These examples represent a very small sample of the existing software production and management tools and environments. It is sufficient to show that at least the environmental and management aspects of the overall problem are being addressed. The problem of the shortage of trained software professionals has not fared as well. With the exception of some part-time curriculum development on the part of the professional societies, and some tuition refund programs in industry, virtually nothing has been done to increase the pool of trained software developers and managers.

The DOD is the largest single "consumer" of embedded software in this country (and the world). The 1983 price tag is expected to be around $7 billion. The DOD has a strong vested interest in improving the quality, performance, and cost of the software it purchases. In April 1979, the DOD made a commitment to the Congress to institute a software technology initiative. That effort proceeded through several planning levels and culminated in a document called "Strategy for a DOD Software Initiative," which was released in October 1982 at the direction of Dr. Edith Martin, Deputy Under Secretary of Defense for Research and Engineering (Research and Advanced Technology). This document was further refined and elaborated at a work-

shop, held in February 1983 in Raleigh, N.C., that was attended by 500 leading software professionals from government, industry, and academia. One of the first acts of the workshop was to give the initiative its "official" acronym—STARS—which stands for "Software Technology for Adaptable and Reliable Systems."

The strategy for STARS is to provide the management action necessary to properly emphasize software and systems issues. It will establish the resources and mechanisms needed to accelerate improvement in the state of software practice for the DOD community. As it is envisioned, the initiative will last for 7 years, going through four separate stages during that time. Stage 0 covered fiscal year 1983, during which the necessary organizing, planning, and studies were to be done. Stage 1 will concentrate on gathering and consolidating those existing techniques that have a proven track record. Stage 2 will provide a period of enhancement for the techniques selected in Stage 1. Stage 3 will concentrate on stabilizing the technology and implementing any advanced techniques uncovered during research funded by STARS or by any other cooperating agency.

In order to concentrate the available resources to the greatest advantage, the initiative has been directed into nine thrust areas: human resources, project management, systems, application specific, acquisition, human engineering, support systems, measurement, and technology insertion.

Human resources will address the elevation of personnel skill levels through education- and knowledge-based automated tools. Project management seeks to improve the skill of software managers and to provide them with automated tools that will assist them in the decision-making process. The systems thrust area deals with computer systems architecture, hardware/software synergy, and systems reliability. The term "application specific" is meant to cover the broad area of reusable software (and/or software design). The acquisition thrust area is the most DOD-oriented topic in that its goals are directed toward ensuring that the government gets a compliant product, on time and within budget. Human engineering will ensure a friendly man-computer interface. The support systems category will deal with the environment in which software is designed, built, tested, and maintained. The measurement thrust has a dual role. It must develop techniques to measure the performance of a software project, and it must apply these techniques to the STARS program to measure its effectiveness. The last category, technology insertion, may be a misnomer in that its principal goal is the establishment of a National Software Engineering Institute, which will be the custodian for STARS and will actively promote its use and improve its performance.

In order to implement its plans for STARS, DOD has committed itself to a budget of nearly $230 million through the end of fiscal year 1988. Although this is a significant sum, it is not unreasonable in light of the magnitude of the projected future cost for embedded software. If the current trend continues, DOD will have a software bill of $32 billion by the year 1990 (see Figure 4). There is little doubt that the use of automated techniques improves both the productivity of software personnel and the quality of their product. There is some disagreement as to the magnitude of the effect, but even the most conservative commentator will accept savings in the 15 percent to 20 percent range. Using this range of values, there is a potential payback that is greater than 30 to 1 for the year 1990 alone. Another way of looking at a capital investment of this sort is to consider other American workers. The investment for each farmer is $75,000; for a heavy-industry worker, it is $45,000; and for the software practitioner, it is between $1,500 and $15,000. If we want to improve the productivity of people involved in the software process, we must make the necessary capital investment.

DOD could always employ a strategy of letting the marketplace develop a "STARS" as a matter of practical necessity. This would result in a profusion of approaches which, at best, would address only part of the total problem. The matter of the shortage of software professionals, for example, would, in all probability, continue to be ignored. DOD would also wind up paying for most of the duplicated systems in the form of a cost pass-along in the embedded software it purchases.

In conclusion, it is obvious that something must be done to reduce the cost of the software component of our weapon systems and at the same time improve its quality. As the largest customer in this country for such software, it is altogether proper for DOD to lead our efforts in that direction. It is no longer feasible to allow software development to proceed as an individual art form. It is time for it to mature as a disciplined and controlled engineering activity.

The Military and Academia Benefitting from

William Voelker

The U.S. Army Corps of Engineers is the largest building-procurement industry in the world, and the University of Illinois School of Architecture is one of the largest and oldest programs of its kind in this country. Each year, the Corps' Military Construction Army (MCA) program incorporates hundreds of projects consisting of some 50 facility types in various stages of planning, design, and construction. For the past several years, such construction has been growing rapidly in volume and in technical complexity. Within this context, the Corps of Engineers must design the best possible facilities, reuse the successful design elements whenever possible, and manage the related construction programs to capitalize on the repetition involved. The Corps, principally through its Construction Engineering Research Laboratory (CERL), at Champaign, Ill., gains improved quality and efficiency by using automated tools such as Computer-Aided Engineering and Architectural Design Systems (CAEADS). ': was natural for the Illinois School of Architecture to consider CERL a tremendous resource upon which to draw.

The desire to have computer-aided systems support the military planning and design process is a long-standing one. The earliest efforts were centered around an approach known as the Automated Engineering and Architectural Design System (AEADS). The stated objectives of AEADS were to develop automated procedures to assist the engineer districts in master planning, architectural and engineering design, cost estimating, life-cycle costs, and construction specifications, and to develop and implement a single, computer-aided engineering and architectural design system that integrates and coordinates the various design disciplines and functions.

New Thrust in '76

In 1976, AEADS was renamed CAEADS and was reoriented and redirected toward providing an approach to a computer-aided system flexible enough to accept incorporation of future computer technology as it developed. A number of factors forced delays and revisions in parts of the CAEADS development. As a result, the effort was refocused in late 1980 to provide what has become known as Preliminary Concept CAEADS (PCC), which has a mid-1980s target date for useability testing.

Concept CAEADS is intended for use at the early stages of design, primarily in the functional layout and analysis phases. Its full development should help architects, engineers, and estimators manage design evolution up to the 35 percent design level of the MCA cycle. Part of the challenge in developing the system is to define precisely what constitutes the 35 percent level of design completion.

Concept CAEADS operates on computer services at the University of Michigan and has a link to the Boeing Company. Data from the Michigan site are transferred by normal remote-job-entry procedures. The system is made available by a telephone hook-up through worldwide communications networks; the only equipment required at a work station is a graphics display terminal, such as the Tektronix 4014, and a hard-copy printer. System capability has recently increased from 1200 baud to 9600 baud.

Such a system, which is without equal in terms of total planned capability, generated great interest at the University of Illinois School of Architecture. Professor Walter Lewis of that school began developing contacts between CERL and the school that have evolved into a positive working relationship. Professor Lewis' area of specialization is technology/practice, and others, like myself from the design community, have come aboard to specialize in our various areas of expertise.

CAEADS Subsystems

The following items tabulate the CAEADS subsystems with a brief explanation of the purpose and function of each.

DD 1391 Processor is intended to help the using service and the facilities engineer prepare MCA project submittals. It produces budget estimates and ensures that project submittal information is complete and consistent. Data bases of all DD Form 1391s, including the status and comments at each review level, are maintained. The data used directly in CAEADS here are the project description, scope, location, type, and the detailed requirements.

DIS (Design Information System) identifies which proposed MCA proj-

■ *Mr. Voelker is an assistant professor in the School of Architecture, University of Illinois at Urbana-Champaign.* ■

ects are most suited to a standard design solution. Specific project information from the DD 1391 processor is compared against actual, standard, definitive designs in the DIS library; then DIS tells the designer which existing designs are capable of being used.

SKETCH (Computer-Aided Facility Layout System) facilitates the designer in laying out and entering two-dimensional graphic building description information into CAEADS. The designer may either retrieve standard designs for modification or begin with original ones using the graphics terminal. The screen is divided into a sketching area, a menu of commands, and an area for alpha-numeric dialogue. SKETCH can be used to manipulate modular components and then to combine them repetitively into a larger plan.

SEARCH (Systematic Evaluation of Architecture) evaluations are under development to improve the architectural design review process at Corps district and division levels, the Office of the Chief of Engineers. These ensure facility design compliance with the design criteria provided by the 10 design guides, technical manuals, codes, and other documents. The current SEARCH system reviews floor-plan layouts (as input through SKETCH into the Concept CAEADS data base) for compliance with the following measurable functional criteria:

- Existing capabilities
  - Maximum and minimum areas
  - Acoustic separation
  - Walking distances
  - Visual control
  - Accessibility to handicapped
  - Fire safety
  - Equipment inventories
  - Solar feasibility
  - Spatial efficiency
- Capabilities under development
  - Occupant load requirements
  - Physical security
  - Noise control
  - Energy conservation
  - Service subsystem terminal elements

BLAST (Building Loads Analysis and System Thermodynamics) is a comprehensive set of programs for predicting energy consumption, system performance, and cost in both new and retrofit building designs. It helps designers perform peak load (design day) calculations. By estimating the annual energy performance of a facility, BLAST can be used to evaluate and compare building design alternatives. Then, alternative designs can be evaluated, modified, and reevaluated, ensuring that the final design is a net conservator energy.

BLAST, as a part of Concept CAEADS, requires little user input to perform an energy budget analysis in SKETCH. The mechanical design engineer merely enters a system design description, including (1) the thermal zone layout; (2) fan and plant assignments; and (3) walls, floors, ceilings, and roof materials. The BLAST input program (BIP) then prepares a run deck for BLAST, and the user selects the building operating schedule, the simulation period, and the types and sizes of mechanical equipment elements. BIP will automatically input the necessary building description information from the SKETCH data base, plus the weather pattern information relevant to the project location.

ABES (Automated Budget Estimating System) gives the designer a direct project cost estimate during the early phases of design. This makes it possible for the designer to anticipate and control the overall project cost elements, and to efficiently perform life-cycle cost tradeoffs (deciding, for example, whether to incorporate solar-energy systems).

ABES prepares a preliminary estimate by extracting 12 basic parameters from SKETCH, such as building type, gross floor area, basic energy source, and the number of floors in the building. Then, ABES generates a detailed list of construction tasks and quantities required to price the building. These items generated by ABES are subsequently fed into CACES, which generates a direct cost estimate.

ABES was developed using the systems format, which builds a structure from all ABES construction tasks within a sequence similar to that of actual construction. Thirteen building systems are used to combine into a facility description, and each system comprises subsystems that, in turn, comprise assemblies.

During the next few years software will be developed to support integrated predesign activities under a unified Predesign CAEADS. These next phases are still in the planning stage. Current plans include the following possible items:

The Project Development Brochure (PDB) Processor will be similar to the 1391 processor and it will provide support in organizing specific project data.

The Computer Evaluation of Utility Plans (CEUP) System and the Installation Graphics Analysis System will be used to determine the capacity of utility systems to meet increased demands resulting from new construction projects.

The Environmental Technical Information System (ETIS) will be used to determine the environmental impacts of new construction and its subsequent operation and maintenance, and will be available as a stand-alone system.

The Pollution Abatement Management System (PAMS) is a specialized

system for considering pollution abatement alternatives and will be used to determine which abatement technologies are appropriate for both new and retrofit projects.

The Installation Facility Mobilization Planning System will be used to analyze the effects mobilization will have on installation facilities and their supporting utilities.

CACES (Computer-Aided Cost Estimating System) is designed to give detailed cost estimates of a project in the advanced stages of design as a part of final-design CAEADS. It uses quantity takeoffs along with associated labor, equipment, and shipping costs to produce overall cost estimates. Various cost data bases are maintained and can be modified as needed—for example, with reference to the actual region of construction. Construction categories in CACES are intentionally similar to those in EDITSPEC (see below).

EDITSPEC (Computer-Aided Specification Preparation System) is also part of final-design CAEADS. It simplifies preparation of project construction specifications as based on existing and updated Corps of Engineers requirements. The system is expected to save at least $2 million per year by reducing specification production costs and the number of change orders, while doubling specification writer and typist productivity.

In EDITSPEC, the writer simply has to mark a computer-generated list of project design conditions, and the program will automatically pull all pertinent guide specification text and place it in the correct location within the project specification document. EDITSPEC then prints all specifications—formatted, paragraphed, and paginated.

Conclusion

During the late 1950s, in the aftermath of Sputnik, research money was flowing steadily to mathematics departments at major universities. Some pushed aside this opportunity to enter applications research in computers and chose instead to focus on theory. Today, many of these departments regret that action.

Architectural schools and departments now find themselves in a similar situation. They must not allow financial exigencies to cause them to push computers aside, and computer-aided design tools have come of age. They promise to be the spark for the first total revolution in the way societies design and construct their buildings. Architects working over wide geographic areas are responsible for coordinating vast amounts of information in each project; thus, they stand to benefit more than people in other areas of expertise.

This transition will create special challenges for architectural schools. Perhaps the most salient challenge will be to manage the competing professorial interests that will surely be vying for access to the hardware. It will, be mandatory for a school moving into automated design tools to place at the top of its priorities a computer "librarian." This person will be knowledgeable about both computers and architecture and will have experience in dealing with and controlling competing interest groups.

The use of computers can be highly compatible with the standardization of design, as the Illinois school has seen with CAEADS. Standard and definitive designs can be retrieved and can be quickly and easily modified, and/or combined into modules. In the proper hands, this could lead to less complicated, easier-to-build architecture with enhanced visual harmony. The very traits that facilitate use of the computer can result in a more organized and repetitive, but nonetheless exciting, architecture. It is fun to design on the computer—the danger that must be avoided is the potential for producing bad architecture faster.

The existing links between USACERL and the University of Illinois School of Architecture in CAEADS have been valuable for both the campus institution and the governmental agency. Both feel strongly that the use of appropriate computer-aided design hardware and software will enhance both the student and the "real-world" design process. The user-friendly device placed at the disposal of the design student or professional can increase the level of productivity, the response to client needs, and the ease of review.

(Continued from page 37)

A Word About OERs

Don't shy away from this one. It's a difficult subject, but one you must discuss. Determine the extent of the individual's knowledge about Officer Efficiency Reports (OERs) and then fill in any gaps that may exist. Let each new officer know who will be his or her rater, additional rater, and endorser. If possible, discuss the level of possible endorsements, and the circumstances and likelihood of escalation. Some lieutenants have well-defined goals, and they need to know the avenues toward achieving them. You are an important source to help identify these avenues—and quality OERs can help them reach their goals.

A Final Word

Sum up this initial counseling session with your considered and honest feelings about your profession, and conclude your session with an expression of confidence in the young officer. Be sure to make known your availability and willingness to help in any way you can.

We want to emphasize that, while we believe these sessions with second lieutenants are extremely important in getting them started in the right direction, counseling interviews for *every* officer entering your organization are important for the success of the organization and the individual. Some of the points discussed here could also be of use for such interviews, adapted as necessary.

Counseling interviews for new lieutenants coming into your organization are a critical element of each supervisor's leadership responsibilities. These interviews should be designed to inform, but they should also motivate them to be positive, useful contributors to their organizations and to their services.

These interviews are time-consuming, but the planning and the hour or so they take will be more than worth the time in terms of the benefits they yield. We encourage every supervisor to give these interviews their best efforts. You won't regret it.

An explanation of the "reason for being" of OFPP, which has been authorized to continue operation at least through 1987

■ *Editor's note: Dr. William N. Hunter, former Director of the Federal Acquisition Institute and current occupant of the Office of Federal Procurement Policy Chair in the DSMC Executive Institute, uses this space to keep* Program Manager *readers informed about the activities of the Office of Federal Procurement Policy (OFPP).* ■

The Commission on Government Procurement, in its 1972 report to Congress, recommended establishment of the Office of Federal Procurement Policy because of the magnitude and budgetary significance of the procurement function, and the void in policy leadership to oversee and direct it. Two years later, Public Law 93-400, "The Office of Federal Procurement Policy Act," was enacted. It established OFPP in the Office of Management and Budget (OMB) to provide overall direction of procurement policy; to prescribe procurement policies, regulations, procedures, and forms for executive agencies; and to coordinate programs to improve the quality and performance of procurement personnel.

With the enactment of Public Law 96-83, "The Office of Federal Procurement Policy Act Amendments of 1979," the OFPP was reauthorized by Congress for 4 additional years. The Act confirmed the fundamental mission of OFPP, but withdrew its authority to issue procurement regulations—in favor of relying on the procurement regulatory agencies (Department of Defense, General Services Administration, and National Aeronautics and Space Administration) to perform that function.

Public Law 98-191, which the President signed on December 1, 1983, reauthorized OFPP through fiscal year 1987, and confirmed its traditional mission and functions. In particular, the law reaffirmed the administrator's authority to issue policies "which shall be followed by . . . executive agencies. . . ." It also reinstated OFPP regulatory authority, but limited its use to those situations when the procurement regulatory agencies are unable to agree on, or fail to issue, regulations in a timely manner.

Functions

The principal functions assigned to the OFPP by statute include the following:

—Providing leadership and ensuring action by the executive agencies in the establishment, development, and maintenance of the single system of simplified government-wide procurement regulations, and resolving differences among executive agencies in the development of simplified government-wide procurement regulations, procedures, and forms.

—Coordinating development of government-wide procurement system standards that shall be implemented by the executive agencies in their procurement systems.

—Providing leadership and coordination in the formulation of the executive branch position on legislation relating to procurement.

—Providing for a computer-based Federal Procurement Data System, which shall be located in the General Services Administration (acting as executive agent for the Administrator for Federal Procurement Policy) and shall collect, develop, and disseminate procurement data.

—Providing for a Federal Acquisition Institute, which shall be located in the General Services Administration (acting as executive agent for the Administrator for Federal Procurement Policy) and shall (1) foster and promote government-wide career management programs for a professional procurement work force; and (2) promote and coordinate government-wide research and studies to improve the procurement process and the laws, policies, methods, regulations, procedures, and forms relating to procurement by the executive agencies.

—Establishing criteria and procedures to ensure effective and timely solicitation of the viewpoints of interested parties in the development of procurement policies, regulations, procedures, and forms.

—Developing standard contract forms and contract language to reduce the government cost of procuring property and services, and the private sector cost of doing business with the government.

—Completing action, as appropriate, on the recommendations of the Commission on Government Procurement.


Braunstein


DeCoursey

Gains

Marya K. Braunstein is a Professor of Systems Acquisition Management, Technical Management Department, School of Systems Acquisition Education. She is a co-founder and, previously, was executive vice president of ANA-LOG, Inc., a logistics consulting firm. Ms. Braunstein holds a B.A. degree from Emmanuel College, Boston, and an M.B.A. degree from Boston University.

Donald W. DeCoursey is a Professor of Systems Acquisition Management, Acquisition Management Laboratory, School of Systems Acquisition Education. He came to DSMC from the Naval Electronic Systems Command where he was with the REWSON System Project Office (PME107). Mr. DeCoursey holds a B.S. degree in aeronautical engineering from the University of Illinois, and an M.S. degree in aeronautical engineering, as well as an aeronautical engineer's degree, both from the Naval Postgraduate School.

Retired

J. Stanley Baumgartner, Department of Research and Information, retired. The family has moved to Lake San Marcos, Calif., where Mr. Baumgartner will remain involved in controls for defense and non-defense programs.

Lieutenant Colonel Alan W. Beck has retired from the U.S. Air Force after serving at DSMC since June 1980 in the Business Management Department, School of Systems Acquisition Education. He was the department's Deputy Director. Mr. Beck has returned to DSMC as a civilian and is a Professor of Financial Management in the same department. He was graduated from Kenyon College, where he received a B.A. degree in economics in 1963. He also holds an M.A. degree in electronics from St. Mary's University.

Lieutenant Colonel William J. Niemann, USAF, retired. He is a senior consultant in performance measurement at John M. Cockerham & Associates, Huntsville, Ala.

Lieutenant Colonel Dean I. Rhoads, USAF, School of Systems Acquisition Management, retired.

Losses

Terry A. Carlson, School of Systems Acquisition Education, resigned to form a C.P.A./consulting firm in Burke, Va. He will specialize in consulting with government contractors.

Linda Hammond, School of Systems Acquisition Education, resigned. Her husband, Marine Major David Hammond, has been assigned to 29 Palms, Calif., where they will reside.

Julia A. Rogers, School of Systems Acquisition Education, resigned, to move to Albany, N.Y., where her husband, Jeff Rogers, will work for the Department of Energy.

Carolyn Johnson, School of Systems Acquisition Education, to the U.S. Army Corps of Engineers, Fort Belvoir.

Ann Summers, Department of Research and Information, resigned.

Promotions

Kendra Haugen, School of Systems Acquisition Education, secretary to the Associate Dean, Executive Programs and IRM Systems.

Joyce Howley from School of Systems Acquisition Education, to Executive Institute, Office of the Commandant.

PMC 83-1

Charles M. Wheelock has been promoted to GM-14 and assigned as the division chief within the Active Systems Division, Deputy for Reconnaissance, Strike, and Electronic Warfare, Wright-Patterson AFB, Ohio. Major programs within the Division include PAVEMINT, SEEK RAM, and ASPJ.

PMC 83-2

Ramon E. Jaramillo has been promoted to be Deputy Program Manager for Advanced Ship Systems in the Ship Launched Project Office of the Joint Cruise Missile Project, Washington, D.C. Formerly he was Project Engineer for the Armament Division at the Naval Air Systems Command.

■ *PMC graduates: Send your input for PMC Graduate Update to Inside DSMC, Publications Directorate, Defense Systems Management College, Fort Belvoir, Va. 22060. Be sure to include your PMC class number.* ■

John M. Sheffer was commissioned a Second Lieutenant in the U.S. Army upon completion of Officer Candidate School at Fort Benning, Ga. Formerly a Specialist Five illustrator in the DSMC Graphics Division, he is now attending the Basic Armor Officer Course at Fort Knox, Ky. Upon graduation at the end of September he will be assigned to a unit in Germany.